COMMONWEALTH BUREAU OF HELMINTHOLOGY,
THE WHITE HOUSE,
103, ST. PETER'S STREET,
ST. ALBANS, HERTS.
31.12.62.

Vol. 43, No. 3, 1961

THE MALAYAN AGRICULTURAL JOURNAL

PRINCIPAL CONTENTS

VIRGINIAN TOBACCO IN KELANTAN. *By L. A. Vivian.*

UPTAKE OF NUTRIENTS BY PADI VARIETY PEBIFUN. *By K. Kanapathy and S. Thamboo.*

VARIETY TRIALS OF SERDANG CACAO IN MALAYA. *By A. V. Hadden.*

SUCCESSFUL INOCULATION OF OIL PALMS WITH A PURE CULTURE OF GANODERMA LUCIDUM. *By S. J. Navaratnam.*

A NOTE ON INTESTINAL PARASITES IN SOME CHINESE CARPS. *By Joe I. Furtado.*

MINISTRY OF AGRICULTURE AND CO-OPERATIVES
Federation of Malaya
Kuala Lumpur

PRICE $2

DEPARTMENT OF AGRICULTURE, FEDERATION OF MALAYA

ORGANISATION (as on 31st December, 1961)

Director of Agriculture:—J. S. Ure, B.Sc., D.T.A. (*Acting*).
Deputy Director of Agriculture:—Mohamad bin Jamil, B.Sc., D.I.C.T.A. (*Acting*).
Senior Agricultural Officer (HQ):—Van Thean Kee, B.Sc. (Hons.) (Wales) (*Acting*).
Executive Officer:—Yap Sin Hee.

RESEARCH BRANCH

Assistant Director (Research):—
A. R. McWalter, B.Sc. (Hons.).

Executive Officer:—
K. Nagapen.

(II) BOTANY

Senior Botanist:—
A. V. Haddon, B.Sc. (Hons.), Dip. Agr. Sc. (Cantab).

Plant Breeders:—
Tang Teng Lai, BA, Dip. Agr. Sc. (Cantab.).
N. Thirunavukarasu, B.Sc. (Hons.).
Two vacancies.

Plant Physiologists:—
Jamaludin bin Lamin, B.Sc. (Hons.) (Edin.). (*Temporary*).
One vacancy.

Asst. Research Officers:—
Sulan bin Salleh.
Mohd. Yusoff bin Zakaria.

(III) CHEMISTRY

Senior Chemist:—
G. W. Arnott, B.Sc. (Hons.), D.T.A.

Canning Officer:—
One vacancy.

Chemists:—
Lim Chin Lam, B.Sc. (Hons.).
One vacancy.

Assistant Chemist:—
One vacancy.

(IV) SOIL SCIENCE

Senior Soil Scientist:—
W. P. Panton, A.M.N., B.Sc., (Hons.), D.T.A.

Soil Scientists:—
K. Kanapathy, B.Sc. (Hons.) (Annamali), M.Sc., A.R.I.C.
Ng Siew Kee, B.Sc., (Hons.), Ph.D., (London).
Three vacancies.

Asst. Research Officer:—
S. Thamboo.

FIELD BRANCH

Assistant Director (Field):—
Chew Hong Jung, B.Sc., B. Agr. (QUB).

Agricultural Economists:—
* T. B. Wilson, M.A. (Oxon.), Dip. Agric. Econ., D.T.A.
* S. Selvadurai, B.A. (Hons.).

Agricultural Officer:—
* Mohd. Tamin bin Yeop, B.Sc. (Agr.) (Edin.).

Personal Assistant to Asst. Director (Field):—
Yoon Weng Kong.

KEDAH: *State Agricultural Officer*:-
Mohd. Noor bin Wahab, B.Sc. (Agr.), (Dunelm.) (*Acting*).
Agricultural Officer:—
Vacant.
Asst. Agricultural Officer:—
Muhammad bin Arshad

PERLIS: *State Agricultural Officer*:—
Tengku Mansur bin Tengku Ya'acob, B.A. Agr. (Cantab).

KELANTAN: *State Agricultural Officer*:—
G. F. Darnell, B.Sc. (Agr.), Dip. Agr. Sc. (Cantab)., D.T.A.
Agricultural Officer (Vacant).
Hj. Mahmood bin Haji Yaacob, S.M.K. (*assisting*).
Asst. Agricultural Officer:—
Hj. Mahmood bin Haji Yaacob, S.M.K.

TRENGGANU: *State Agricultural Officer*:—
Wan Mohd. Don bin Mohamad, B. Agr., A.M.I. Agr. E.
Asst. Agricultural Officer:—
Mohd. Noor bin Haji Abdul Hamid.

PENANG & PROVINCE WELLESLEY:
State Agricultural Officer:—
Basir bin Ismail, P.J.K., B.Sc. (Agr.) (Dunelm).
Asst. Agricultural Officer:—
Mohd. Noordin bin Mohd. Kassim.

PERAK: *State Agricultural Officer*:—
Omar bin Buyong, B. Agr.
Agricultural Officers:—
Perak North—Vacant.
Yusof Zainal (*A.A.O. assisting*).
Perak Central—
Zawawi bin Hamzah, B.Sc. (Agr.).
Perak South—Vacant.
Asst. Agricultural Officer:—
Mohd. Ibrahim bin Mohd. Ali.

RESEARCH BRANCH (contd.)

(V) ENTOMOLOGY

Senior Entomologist:—(*Vacant*).
Ahmad bin Yunus, B.Sc., B. Agr. (QUB) (*covering duties*).

Entomologist:—
Ahmad bin Yunus, B.Sc. B. Agr. (QUB).

Asst. Research Officer:—
Kamardin bin Bahar, A.M.N.

(VI) PLANT PATHOLOGY

Senior Plant Pathologist:—(*vacant*)
S. J. Navaratnam, B.Sc. (Hons.) (*covering duties*).

Plant Pathologists:—
S. J. Navaratnam, B.Sc. (Hons.).
Ting Wen Poh, B.Sc. (Hons.).

AGRONOMY BRANCH

Senior Agronomist:—
Ahmad bin Mohd. Amin, BSc. (Agr.), (Edin.)

Agronomists:—
Ajit Singh Sidhu, B.Sc. (Punjab) Ph.D., (Dunelm.).
Chee Sek Pan, B. Agr. Sc.
Ch'ng How Soo, B. Agr. Sc.
Abu Bakar bin Mahmud. B. Agr. Sc.
Goh Khek Boon, B. Agr. Sc.
Four vacancies.

Agricultural Engineers:—
Two vacancies.

Livestock Officer:—
C. Devendra, B. Agr. Sc., (*Pupil*).

Statistician:—
I. Watson, B.Sc., (Hons.). (*On Contract*).

Asst. Statistician:—
* Lee Yoke Heng.

Agricultural Development Officers:—
N. Kanagaratnam.
Ahmad bin Jamal.
Othman bin Mohd. Lela, K.D.S.

Asst. Agricultural Officer:—*Vacant.*

PUBLICATIONS BRANCH

Publications Officer:—(*Vacant*).
Van Thean Kee, B.Sc. (Hons.), (Wales) (*covering duties*).

Librarian:—
P. J. Verghese.

FIELD BRANCH (contd.)

SELANGOR: *State Agricultural Officer*:—
Lee Sin Fook, B.Sc. (Agr.).
Agricultural Officer, Coast (North):—*Vacant.*
Zakaria bin Abdul Rauf, P.J.K. (*A.A.O. assisting*).
Asst. Agricultural Officer:—
Zakaria bin Abdul Rauf, P.J.K.

PAHANG: *State Agricultural Officer*:—
R. J. R. Barrett, B.A. (Hons.) (Cantab.). Dip. Agr. (Cantab.).
Agricultural Officer:—*Vacant.*
Asst. Agricultural Officers:—
Pahang North—
Ng Ngok Wah.
Pahang East—
Mohd. Muda bin Mahmood.
Agronomist i/c F.E.S. Cameron Highlands:
Ani bin Arope, B. Agric. Sc. (N.Z.).

NEGRI SEMBILAN:
State Agricultural Officer:—
Khalid bin Abdul Rahman, B.Sc. (Agr.).
Asst. Agricultural Officer—Vacant.

MALACCA: *State Agricultural Officer*:—
Mohd. Ridzuan b. Md. Noh, B.Sc., (QUB)
Asst. Agricultural Officer:—
Hj. Ali bin Mohd. Salleh.

JOHORE: *State Agricultural Officer*:—
P. Class, B.Sc. (Agr.), D.T.A.
Agricultural Officers:—
Johore Central—
Aw-Yong Kong Keong, B.Sc. B. Agr. (QUB).
Johore West—Vacant.
Johore North—Vavant.
Asst. Agricultural Officer, Johore South:—
Tan Guan Chye.

AGRICULTURAL EDUCATION BRANCH

Principal, College of Agriculture, Malaya:—
G. I. M. Martin, B.Sc. (Agr.), Dip. Agr. (Cantab.), D.T.A., S.D.D.H., (*Acting*).

Senior Lecturers:—
Ahmad b. Baba, B. Agr. Sc.
Chin Hoong Fong, B. Agr. Sc.
Two vacancies.

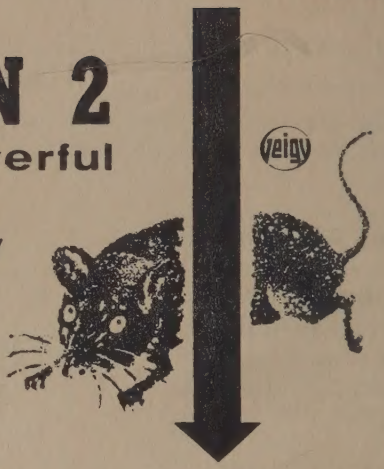
Registrar and Bursar:—
Yap Chin Hee, J.M.N.

Assistant Lecturers:—
G. R. Kurup, B.A.
Abdul Hamid bin Haji Hussein.
Haji Abu Hassan bin Sidong.
Abu Bakar bin Mohd. Tahir.
Tamin bin Hussain.
Mrs. V. Thomas, B.Sc., M.Sc. (Madras), (*Temporary*).

* Seconded to Malayan Agricultural Census Division, Ministry of Agriculture.

TOMORIN 2

the most powerful RAT - KILLER on sale today



Tomorin 2 in a NEW bait concentrate and is the most effective rat killer available for large-scale control on oil palm estates, padi fields, and in godowns etc. Tomorin 2 kills rats speedily by anticoagulant action. Instruction leaflets are available from the agents and distributors.

Diazinon Geigy the safe versatile insecticide

Diazinon kills most insect pests, even those resistant to other types of insecticide. A single spray maintains hygienic insect free conditions for several months. Safe to use, Diazinon brings the practical benefits of insect control in hospitals, hotels, labour lines, warehouses, ships and industrial premises. Information and supplies of Diazinon formulations from

Agents:

FISONS CHEMICALS (MALAYA) LIMITED, P.O. Box 1007, Ampang Road, Kuala Lumpur.

Distributors: HARRISONS & CROSFIELD . . . all branches.

SHELL
Your cup is full...
the result
of care when
replanting
The new high yielding
stock cannot realise
its full potential
unless areas are
cleared of lallang before
replanting. Complete eradication
of lallang is essential. The best and
safest way to eradicate lallang is spraying
and wiping with . . . .
SHELL LALLANG OILS

around the clock...

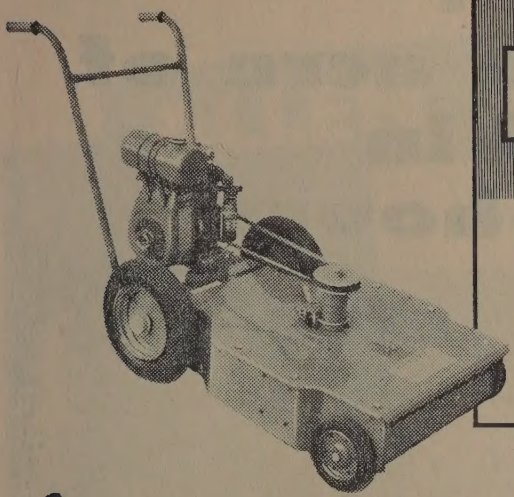
For further information on pest control, please consult your nearest Shell branch.

Night and day . . . subterranean termites carry on their life cycle — multiplying, spreading and doing untold damage to young rubber trees. Termites can be effectively controlled with dieldrin.

Use Dieldrex 15, an emulsible form of dieldrin, at the rate of 2 fluid ounces in 3½ gallons of water. The residual effect is long lasting.

the ideal estate insecticide **Dieldrex 15**

SHELL

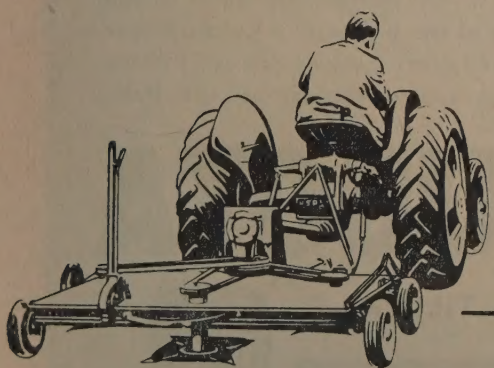


HAYTER ROTARY Grass Cutter

Sooner or later you'll buy - a HAYTER

FOR ROUGH CUTTING TO ALMOST LAWN FINISH.

The "Hayter" Motor Scythe, illustrated as above is in its element in tough grass or lallang, on padang, sports field or private lawn. Of sturdy build, and easy to handle, the "Hayter's" cutting height may be quickly and positively adjusted. The actual cutters may be quickly sharpened with an ordinary reaper file. Powered by a MARK 12 – 4 - stroke – "Villiers" engine (guaranteed 6 months), this is a scythe you can rely on.



The heavier model, at left, is an invaluable machine on Plantations, Estates, Padangs and Airstrips. We would welcome the opportunity of discussing this machine's advantages with you.

SOLE AGENTS

JAMES WARREN

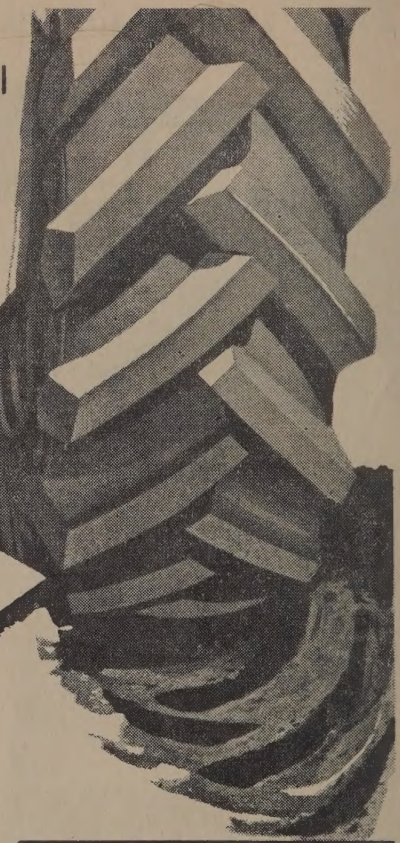
KUALA LUMPUR — SINGAPORE — IPOH

GOODYEAR

'Torque Control' saves work and fuel

TRACTION SURE-GRIP

Delivers Traction-Action at the point of power



Much of the power that your tractor produces will never get to the drawbar if its wasted by tyres that don't gear themselves to the soil, as they should. This never happens with Goodyear's TRACTION SURE GRIP This is the tyre that grips like a gear, that harnesses torque and puts it to work to give you more positive action on less fuel. Look at these features. Tough triple-tempered 3T. cord construction to resist distortion and cracking. "Wedge-Grip" Action – massive extra deep lugs come closer together at the shoulder to take wedge-in bites. Tapered, more heavily buttressed lugs specially angled to prevent scuffing action. Open centre – completely self cleaning.

TO COMPLETE THE TEAM

A Goodyear front wheel tractor tyre 'Super Rib' with high centre and side ribs in wide tread gives unequalled steering

GOODYEAR

the greatest name in rubber

Advertisement

WANTED for MURDER!!

An Anopheline mosquito, a vector in Malaria.

ARRESTED by 'GAMMEXANE' 26 DP

the new concentrated Dispersible Powder containing **26% gamma BHC.**

An effective and the most economical insecticide for the control of mosquitoes.

ICI

'GAMMEXANE'

The Basis of Modern Insect Control

Advertisement

THE ESTATE SCENE

PEST CONTROL

Bothered by slugs and snails?

'Metadex', a concentrated metaldehyde formulation, when used with suitable bait will quickly bring them under control.

We can also offer, in limited quantities, specially prepared ready-to-use tablets containing **'Metadex'.** These tablets have been designed for use under heavy rainfall conditions and should prove ideal both on the estate and in the garden.

ICI

THE

Malayan Agricultural Journal

Edited by the Publications Officer
with the assistance of the Publications Committee.

Vol. 43, No. 3 **1961**

Page

Editorial 141

ARTICLES

Virginian Tobacco in Kelantan. *By L. A. Vivian* 144

Uptake of Nutrients by Padi Variety Pebifun. *By K. Kanapathy and S. Thamboo* 160

Variety Trials of Serdang Cacao in Malaya. *By A. V. Hadden* 169

Successful Inoculation of Oil Palms with Pure Culture Ganoderma Lucidum. *By S. J. Navaratnam* 233

A Note on Intestinal Parasites in some Chinese Carps. *By Joe I. Furtado* 239

Research Branch Laboratory Extension 242

STATISTICS

Market Prices and Production for Selected Agricultural Products 243

Meteorological Summaries 251

THE MALAYAN AGRICULTURAL JOURNAL

The Journal is designed to present — as far as possible in non-technical terms — the results of the agricultural research, investigation and extension work performed by the Department of Agriculture and it draws attention to the results of work of a similar nature in other countries.

The price of the Jounal is $2/- per copy or $8/- per Volume of four issues, post free, in Malaya; it is $8.50 or £1 sterling, post free, outside Malaya.

The Journal and other publications may be obtained from the Director of Agriculture, Kuala Lumpur, Federation of Malaya, or from the office of the High Commissioner for Malaya in the United Kingdom, Malaya House, London, W.1.

COMMITTEES OF THE DEPARTMENT

The Standing Committee on Investigations:

The Deputy Director of Agriculture. **(Chairman).**
The Assistant Director of Agriculture. (Research).
The Assistant Director of Agriculture. (Field).
The Senior Agronomist.
The Agricultural Officer, Headquarters. (Secretary)

The Publications Committee:

The Director of Agriculture, Federation of Malaya. **(Chairman).**
The Deputy Director of Agriculture.
The Assistant Director of Agriculture. (Research).
The Assistant Director of Agriculture. (Field).
The Senior Agronomist.
The Publications Officer. **(Secretary).**

The Examinations Board:

The Deputy Director of Agriculture. **(Chairman).**
The Assistant Director of Agriculture. (Research).
The Assistant Director of Agriculture. (Field).
The Senior Agronomist.
The Principal, College of Agriculture, Malaya.
The Executive Officer. **(Secretary).**

The Advisory Council, College of Agriculture, Malaya:

The Hon'ble Dato' Haji Mohamed Noah bin Omar **(Chairman)**
Inche Abdul Aziz bin Yeop, Permanent Secretary to the Ministry of Agriculture and Co-operatives, Fed. of Malaya, K.L.
Mr. J. S. Ure, Director of Agriculture, Federation of Malaya, K.L.
Inche Johari bin Haji Mohamed Daud, Director of Veterinary Services, Federation of Malaya, Kuala Lumpur.
Inche Mohamed Zain bin Abdul Rashid, Principal, Sultan Idris Training College, Tanjong Malim, Perak.
Mr. G. I. M. Martin, Principal, College of Agriculture, Malaya.
Dr. C. C. Webster, Director, Rubber Research Institute of Malaya.
Inche Chan Hin Cheung, Representative of the Malayan Estate Owner's Association.
Inche Lee Yew Siong, General Secretary, Alumni Association of the College of Agriculture, Malaya.
Dato Jaafar bin Mampak, J.P.
The Hon'ble Inche Hashim bin Awang, J.P.
Inche Jamaludin bin Aji.
Dato Gunn Lay Teik, Representative of the Rubber Producers' Council Federation of Malaya.
Inche Yap Kim Hock, J.P.
The Hon'ble Inche Mohamed Ismail bin Mohamed Yusof.
Inche Yap Chin Hee, Registrar & Bursar, College of Agriculture **(Secretary)**

The Efficiency Bar Board:

The Deputy Director of Agriculture. **(Chairman).**
The Hon'ble State Secretary, Perak.
The Hon'ble State Secretary, Negri Sembilan.
The Representative of the Federal Government.
The Executive Officer. **(Secretary).**

THE

Malayan Agricultural Journal

Vol. 43, No. 3—1961

EDITORIAL

A considerable time has lapsed since the last issue of the Malayan Agricultural Journal Vo. 43, No. 2 was published. We had endeavoured to publish this journal on schedule, but due to difficulties beyond our control we offer once again our sincere apologies for the delay in compiling this issue. The heavy demands on the limited staff of the Division of Agriculture, Ministry of Agriculture and Co-operatives, Federation of Malaya, towards many urgent problems at the present development of the country has necessitated the inevitable irregularity of the appearance of this journal. The publication of the present issue was made possible by officers of the various branches of the Division of Agriculture, who have devoted extra time to their normal duties.

The irregular publication of the Malayan Agricultural Journal is likely to continue for some time, as a result of which it is felt that the section on "Notes on Current Investigations and Extension Work" covering a fixed period be best left out altogether until the resumption of regular publication and that only original articles of scientific interest be published. This does not mean that there is any lowering of the standards. On the contrary the dropping out of the section on "current notes", and the inclusion of as many scientific papers as possible into one issue will make this publication a truly scientific journal. Current investigations, extension work and the overall activities of the Division of Agriculture are published in greater detail in the Annual Report of the Division of Agriculture and readers, therefore, who are interested in this section will find it more profitable to refer to the more detailed account in the Annual Report than the very brief summary hitherto published in the Malayan Agricultural Journal.

Variety Trials of Seedling Cocao in Malaya. It is some years since an article on cacoa was published in this journal, and the one now presented by A. V. Haddon is a timely reminder of the "back room" research which must precede the development of any new crop. The cocoa breeding work has been extremely successful and the new hybrid seed is confidently expected to yield more than twice as much as the previously recommended variety. It is, therefore, particularly unfortunate that the potential threat from "die-back" is still so great

that cocoa cannot be recommended for planting in some of the new Land Development Schemes. An answer to this problem will hardly be found until staff can be spared from research into the cultivation of the major crops such as rice, oil palm and coconuts but on the other hand cocoa research cannot be neglected and will have to be resumed as soon as the necessary staff can be found in view of the demand for crops other than rubber becomes more imperative every year.

Virginia Tobacco in Kelantan. The dense population of the Kelantan Plain depends almost entirely on the income from rice crop for their livelihood. An income from such a source is low because several months of the year following each harvest the rice fields are non-productive. Farmers' income could materially be increased if a crop could be grown during the off-season. The climate of Kelantan during the off-season is suitable for raising a tobacco crop, but unless quality leaves could be produced, the income derived from tobacco would not be commensurate with the labour expended. Quality and yield of tobacco leaves are dependent upon the quantity and type of fertilisers used. Very little work of this nature has been done in Malaya and the paper by L. A. Vivian described the results of an exploratory trial to compare the efficacy of the amount and type of mixture used for the cultivation of tobacco in Kelantan. Attention is also drawn to the need for further research in this field.

Uptake of Nutrients by Padi Variety Pebifun. Adequate supply of plant nutrients in the growing of any crop is important to produce the maximum yields. The nutrient requirements, however, depend on a number of factors among which are the type of crop and the variety. To bring out the maximum yielding potential of a crop variety it is necessary to know the nutrient uptake during the various phases of growth of the crop.

Thus in our effort to increase Malaya's rice production through the expansion of areas under double-cropping where the non-photosensitive variety of Pebifun is used for the off-season, and also through the widespread use of fertilisers, the information regarding nutrient requirement and their uptake by padi plants is considered essential in order to enable recommendation to be made on the type, and quantity of fertiliser and also the time of its applications. The article by K. Kanapathy and S. Thamboo give an account of their investigations into this problem. The pattern and the total amount of uptake of nutrients by the rice plant which is indicated in the report will first be confirmed by field investigations before being used as a basis for formulating padi fertiliser mixtures.

Inoculation of Oil Palm with Ganoderma Lucidum. Basal stem-rot of oil palms caused by the pathogen *Ganoderma lucidum* was first recorded in Malaya in 1950 and has since become widespread, constituting the most serious oil palm disease at present. The increasing

importance of oil palms for diversifying agricultural crops in the economy of Malaya has lent added weight to the need for the study of this disease. The short paper by S. J. Navaratnam describes the success so far obtained in reproduction of the disease by artificial inoculations with a pure culture of the pathogen. The stem of the palm has been determined as the probable site of infection. This finding will no doubt be useful information in the further study of the pathogen and the formulation of control measures.

Intestinal Parasites in Some Chinese Carps. The culture of Chinese carp is a long established industry in Malaya and is a prominent feature in agricultural mixed farming as practised by the Chinese in Malaya. The article is therefore of great interest particularly as so little is known of parasitic infestation in cultured freshwater fish in this country. It will no doubt stimulate further studies on the subject.

VIRGINIAN TOBACCO IN KELANTAN

An Exploratory Manurial Trial at the Dry Padi Experiment Station, Melor, 1960

L. A. VIVIAN,
(*former State Agricultiral Officer, Kelantan.*)

Introduction

During 1959 several scattered observation trials on Virginian tobacco totalling about 8 acres, were carried out near Melor and Ketereh, in the district of Kota Bharu, Kelantan, by a local tobacco company. Most of the trials gave disappointing results but some heavy crops were grown and small amounts of leaf were of moderate quality, giving rise to the hope that with investigation, suitable methods for producing regularly good crops of fair leaf might be discovered. Little difficulty appeared to exist in producing heavy crops, but the production of good quality leaf, capable of curing to a bright yellow colour seemed a much more difficult problem.

On the basis of the experience gained in 1959, the trial herein described was devised and carried out.

Description

OBJECTS

To discover what types of fertiliser may be used with a limited amount of animal manure to grow satisfactory yields of high quality

Secondly, to examine whether the interaction between the nutrient ratio and the quantity of fertiliser applied had an effect on leaf quality.

Thirdly, to discover whether a proprietary prilled compound tobacco fertiliser has any advantage over a mechanical mixture of single nutrient carriers with a similar major nutrient ratio.

TREATMENTS

Eight fertiliser treatments were tested against a control with no fertiliser, making nine treatments altogether. All treatments including the control received a basal dressing of two pints of well rotted dung per plant just before planting. The full details of the nine treatments are set out in Table I.

Three nutient ratios were tested. A with $N:P_2O_5:K_2O$ of 1:1:1.6; B of 1:2:1.6; C of 1:2:3; each ratio at two levels, the second level supplying 50% more plant nutrients per plant than the single level. In addition, a mixture D of an identical major nutrient ratio to mixture A, but consisting of mechanically mixed single nutrient carriers was tested at both levels. Mixture A was a proprietary prilled compound fertiliser, and it also formed the basis for mixtures B and C.

Discussion of Treatments

The prilled compound mixture (A) had shown some promise during the 1959 observations and was accordingly chosen as the base fertiliser to which all others were then related. Greater uniformity throughout the fertiliser, slower and more even release of N, and the presence of beneficial minor and trace elements, it was claimed, might confer on the prilled compound mixture (A) greater efficiency than a mechanical mixture of the single nutrient carriers. In case this proved true, the prilled compound mixture (A) was also used as the base for other mixtures (B and C), to be tested containing increased quantities of P_2O_5 and/or K_2O, the different nutrient ratios being obtained by adding appropriate amounts of single nutrient fertiliser. A mixture of nutrient carriers (mixture D) which had the same nutrient ratio as the prilled compound mixture (A) was included to check whether in fact mixture A did possess the special advantages claimed.

The single nutrient carriers used in the mixtures were chosen by reports in literature of their suitability, noting in particular the sulphur requirements of tobacco and the known intolerance of tobacco to excess chlorine. Observation trials in 1959, comparing mixtures with K_2O as muriate, versus K_2O as sulphate, showed a very marked advantage for K_2O as sulphate.

The actual amounts of fertiliser applied were chosen by the experience gained in 1959. 12 grams per plant of mixture A was judged adequate for ensuring fair growth and 18 grams adequate for ensuring vigorous growth. Both of these levels were therefore tested.

The basal dressing of two pints of well rotted animal manure per plant for all treatments was decided upon from the experience gained in 1959, which indicated that this material is of great value during the establishment and early growth, giving an early establishment that could not be matched by fertilisers alone. Furthermore, dung is traditionally used by Kelantan farmers on the small amount of local type tobacco already grown and most farmers own some stock, making animal manure in small quantity readily available, so that even in the event of Virginian tobacco cultivation extending widely, at least small amounts of dung per plant would doubtless continue to be used and could be recommended as a practicable technique.

Noteworthy also are reports in the literature that dung is frequently a most excellent manure for Virginian tobacco and may alone suffice to produce good quality crops under conditions apparently similar to our own. Finally, it was found by observation in 1959 and established beyond any reasonable doubt that with no fertiliser or manure, tobacco made little or no growth at all on Melor soils, thus rendering superfluous the inclusion of a control plot receiving no base dressing of animal manure to prove the point formally.

SITE

A field of 1.8 acres at the Dry Padi Experiment Station, Melor, was selected for the trial. No special soil analyses were done on the site, but it is typical of this very uniform station, detailed soil analysis of which is given in Table II. The soil may be described as clay loam—a little on the heavy side of medium. It is acid, very low in organic matter, nitrogen and easily soluble phosphate and moderately low in easily soluble potash. It is typical of considerable areas of lowland dry padi land in the Kelantan Plain, although probably less fertile than average.

The site was rough grazing for two years under short, poor, naturally occurring grasses prior to planting to tobacco. Half the area received 5 cwts. local slaked lime five months prior to planting. One corner of the field had been a temporary house site for a short period and there was a well nearby. The site has a long history of dry padi cropping with rough grazing and occasional crops of vegetables, a history quite typical of much similar land throughout the Plain.

METHOD

Experimental layout was a randomized block, with eight replicates and nine plots in each block. Plots were three rows of plants with 39 plants per row. The planting distance was 2 ft. 10 inches between rows by 2 ft. 6 inches between plants in the row, giving 828.75 square feet per plot. The plot size was dictated by convenience in management and made the whole trial exactly fit the field after allowing 10 feet empty headlands and avoiding known soil variation across the site of a former ditch.

The land was thoroughly cultivated and planting was done on the flat, not on ridges or beds, as dry conditions were expected. Treatments were applied by placement in the ground at each individual planting point. A saucer shaped depression, approximately 1 foot in diameter and 4 inches deep in the centre was dug by changkol. * The fertiliser was applied in a circular band to the bottom of this depression so as to leave the central area approximately 4 inches in diameter free from fertiliser. The two pints of animal manure as the base dressing and the excavated soil were then sifted in alternately to fill the depression with a more or less uniform mixture of dung and soil. The fill was crowned slightly to be approximately 2 inches above the general field surface level at the planting point.

This method of placement was adopted to reduce possible edge effects by drift and/or wash and/or root spread, and also to encourage deep rotting in preparation for dry weather.

* The local hoe.

The fertiliser mixtures were made up and thoroughly hand mixed at a central store in Kota Bharu, one week before application, using freshly purchased ingredients. Individual tin fertiliser measuring cups for each treatment were made, using 1¼ inches diameter tin tube, each cup being ground down and thoroughly tested until it measured the correct quantity per plant when brim full, that is, after filling and shaking the surplus off.

Planting and Management

Planting of the variety Harison's Special, commenced on the 4th February and ended on the 16th February. The seedlings were raised by a local tobacco company who used carefully managed partially sterilized germination beds, from which the seedlings were pricked out when about 1½ inches high into small *kerek**. This enabled batches of considerable uniformity to be selected for planting in each replicate and care was taken to ensure that any one block was completed in a single day.

The plants were about 4 inches high at planting and they were then watered with a solution of 1 oz. Dieldrex 15 to a gallon of water as an added prophylactic measure against pest attack. The plants were hand watered during the first week and they were shaded with pieces of bent banana sheath during this time to assist establishment. Within two or three days of planting, a light prophylactic spray of Peronox fungicide was given and during the first five weeks of growth, occasional light sprays of Dieldrex 15 and Peronox were given as judged necessary.

Growth

100% establishment was achieved and growth during the first 2 to 3 weeks was excellent. Thereafter, severe drought was experienced, right up to the second harvesting round, after which intermittent showers occurred until harvesting was completed. Table III shows the rainfall on each day throughout the growth of the crop, together with dates of planting and harvesting.

The very adverse weather seriously stunted the crop, greatly reduced the yield and led to premature ripening of the first harvested leaves.

The intermittent rain that fell after the commencement of harvest had a marked, immediate and completely adverse effect on leaf quality, darkening the leaf from all treatments and almost totally eliminating any quality differences between treatments which had appeared previously.

---

* A Kerek is a traditional local pot, or soil block, about 2½ inches diameter and 2 inches deep, composed of loosely mixed soil and dung enclosed in a strip of coconut pinna. The pinna is removed at planting in the field.

Some leaf, nearly ripe when rains fell, rotted on the plant and could not be plucked.

Frog eye spot (*Cercospera nicotianae*) appeared at the third harvesting round and increased in severity throughout harvesting rendering the leaf from the two final plucking rounds, practically unsaleable.

Harvesting and Recording

Leaf from all the plants in each plot were harvested and recorded, no rows or plants being treated as discards. This was done for practical convenience in the field and was considered justified because no edge effects could be discerned by observation when harvesting commenced even where control plots were adjacent to plots heavily manured with nitrogen. Visible differences in leaf quality between treatments were large to begin with, and any small possible loss in precision through harvesting the whole of each plot was judged not likely to seriously affect the significance of the results.

Two to four leaves per plant were harvested at each plucking round as they ripened, and from six to eight plucking rounds were necessary to complete harvesting on any one replicate. Any small quantity of damaged bottom leaf was rejected and weighed separately, otherwise all green leaf from each plot was weighed in the field immediately after plucking. All the leaf for each treatment from all blocks plucked on that particular day was bulked for grading and sale. This was done because no skilled grader was available on the field at every harvesting round to grade the leaf from each plot individually and it was judged not practicable to transport from some plucking rounds up to 72 small lots of leaf to the grading and purchasing centre.

Leaf was sold to a nearby commercial purchasing and barn curing centre on the day of harvest or early the following morning when lots were plucked late in the previous afternoon. The prices obtained varied according to the buyer's commercial judgement of the leaf value and the average price per kilogram of green leaf bulked from each treatment was taken as the measure of grade for the purposes of this trial. The buyer concerned was a person with long experience of the trade in several tropical countries, and his grading was considered to be most reliable. Bright, pale yellow colour of the ripe leaf, size and freedom from blemish by pest, disease or mechanical damage, were the grading yardsticks.

Leaf from each harvesting round and treatment was kept in separately labelled batches through the barn curing process for appraisal by eye after curing and two representative average samples of cured leaf for each treatment were subsequently analysed for their N and K_2O content in dry matter. These results are listed in Table IV.

Results

Notwithstanding the extremely adverse weather conditions which greatly reduced the value of this trial, some results were obtained.

The former house site and the well had a profound effect upon the growth of the tobacco in the adjacent replicates and the two replicates so affected were discarded from the analysis of the trial. Thus the records used are from the remaining six replicates only.

Table V summarizes the yields per acre obtained for each treatment. The quality obtained expressed as price per kg. leaf and the income in dollars per acre are also tabulated.

Yield

All four mixtures showed large increases over the control. Their patterns of responce were similar in that their single doses produced large increases while the increases due to the additional half doses were all proportionally much smaller than those produced by the initial doses. The magnitude of the increases differed, mixtures A, B & D did not show any difference in their increases but all three gave larger increases than mixture C.

Grade

Mixture A produced no increase in the grade of leaf. For mixtures B, C & D the patterns of increase produced by the single and the single plus a half dose were not the same. In all three mixtures the single dose gave an increase in leaf grade over no fertiliser and the three individual increases showed no difference. The additional half dose of mixture D produced a definite decline in leaf grade though still above that of the control, while the additional half doses of mixture B and C both produced further increases in leaf grade. These two additional increases showed that for both mixtures B and C the pattern of increase in leaf grade was linear over the three levels of the mixtures tested, viz. O, 1 and 1½, and showed in conjunction with the responses to the first doses that there was no difference between the responses of mixtures B and C.

Gross Income

In each of the 4 mixtures the first single dose of fertiliser produced a large increase in gross income while the additional half dose produced proportionally a much smaller increase; in fact none of the mixtures showed a detectable increase and the gross income stayed level from the first single dose to the one and a half dose. The four mixtures did vary slightly in the magnitude of their increases in gross income produced by the first single dose; there were no differences in the increases among mixtures A, B and D but all three gave slightly larger increases than mixture C.

Discussion

Leaf quality must be given considerable weight in assessing these results since it is upon this aspect that the whole future size and scope of the potential virginian tobacco growing industry in Kelantan depends, and unless a certain minimum quality can be achieved, no industry may develop.

Secondly, it must be said that although small leaf quality differences did exist between treatments, even the best leaf produced before any rain fell could only be described as of moderate fair quality and far short of excellent. Therefore, the trial did not show the correct nutrient ratio of fertiliser to use and the results are of value mainly in indicating trends to follow in future research.

Thirdly, the buyers of this leaf are themselves operating experimentally and were buying and curing leaf grown on contract experimentally by private farmers and ourselves, whether that leaf was of commercial quality or not. Thus the grades and gross income results are not indicative of a true existing market and are only of value in comparing treatments within this trial. It is with these points in mind that the results must be assessed.

The results in Table V for yield, grade and gross income must be considered together, since each contributes to the whole and no single one is of much value when viewed separately.

It is immediately obvious that without some fertiliser no worthwhile results can be obtained at all, since the control plot, even with a basal dressing of 2 pints dung per plant, showed up obviously the worst on all counts. This is in accord with observational evidence obtained the previous season and farmers' reports on growth of traditional local type tobacco.

It is clear also that mixture A (1:1:1.6) tended on the whole to produce leaf of low quality and can be discarded on these grounds alone, since quality is of prime importance. The single dose of mixture D (1:1:1.6) produced an increase in quality equal to those produced by mixtures B and C but the additional half dose produced a decline in quality. While yields for mixture D were equal to those for mixture B and C only the single dose produced a gross income comparable with that of B.

Mixture C (1:2:3) gave a linear increase in quality with increasing fertiliser. The comparatively low yields obtained from mixture C however, at both levels, more than discount the better grade produced. Since both levels of C gave lower yields than mixtures A, B and D, it appears that perhaps the relatively high proportion of K_2O in this mixture may have exterted a retarding effect on growth and yield of leaf.

Mixture B (1:2:1.6) produced leaf of a quality on a par with that of mixture C and like mixture C the increase in quality was linear with increasing dosage of fertiliser. Yields were also fair for mixture B and on a par with those from mixtures A and D. Mixture B (1:2:1.6) is therefore the most promising.

Comparing mixtures B and C, which gave leaf of similar quality, both are alike in possessing $N:P_2O_5$ ratios of 1:2, compared with 1:1 in mixtures A and D. $N:K_2O$ ratios differ very widely, however, B at 1:1.6 and C at 1:3. Mixture B possessed the same $N:K_2O$ ratio as both mixtures A and D and in fact supplied less K_2O per plant than any other of the mixtures tested. Mixture C, however, had an $N:K_2O$ ratio of 1:3, the widest of any used, and supplied more K_2O per plant than any of the other mixtures tested. Clearly, the widening of $N:P_2O_5$ ratio from 1:1 to 1.2 improved leaf grade whereas the raising of the proportion of K_2O in the mixture thereby increasing the total amount of K_2O supplied per plant, had no apparent effect on leaf grade, but did lower leaf yields. This is the most important finding from this trial and gains some support from chemical analysis data of the cured leaf.

Table IV shows the % N, % K and N:K ratios in representative samples of cured tobacco leaf harvested before and after rain. It must be said that the comparison between samples harvested before and after rain includes such variation as may be due to the fact that the samples are of different leaf, taken from different plants perhaps different blocks and different levels on the same plant, and these effects cannot be separated nor their magnitude estimated. Nevertheless, field observation at the time showed the rain to have an immediate adverse effect on the crop leaf quality in all replicates, treatments and levels of leaf on the plants so that the differences appearing in Table V are very likely due to the rain coming after prolonged drought and perhaps causing a sudden rise in available soil N.

Excepting control, the treatments ignoring levels when arranged in order of increasing leaf N:K ratio seem to fall out in much the same general order as when listed in order of grade, i.e. C, B, D, A, from which it would seem that low N:K ratios may be related to high grade of leaf in this trial. Too much reliance cannot be placed on inferences drawn from this data but it would appear that the N:K ratio in the leaf is correlated with the N:K ratio in the fertiliser and to the amounts of N and K applied, except for treatments B1 and B1½.

The relatively low N:K leaf ratios of treatments B1 and B1½ are possibly being influenced by some other factor and this must be the $N:P_2O_5$ ratio. It would appear that the $N:P_2O_5$ ratio in the fertiliser may be of considerable importance in its effects on leaf N:K ratio. This inference at any rate, does agree with the trial findings that the $N:P_2O_5$ ratio in the fertiliser greatly influenced the leaf grade.

Mixture A did not cause any effect on leaf grade whatever the amount applied. In mixture D, the single level gave significantly higher grade leaf than the one and a half level. Probably, some of the larger quantity of N supplied by D1½ remained available late in the life of the crop and interfered with normal ripening of the leaf. The single level D1, however, supplied less nitrogen, which was probably either used or leached out, or both, earlier in the life of the crop and thus did not exert as much adverse effect on ripening. Mixtures B and C, however, operated the other way, with the B1½ and C1½ levels giving higher grade leaf than the single levels B1 and C1. Perhaps the small quantities of N supplied by treatments B and C were in the case of C inadequate for normal healthy growth and ripening and in the case of B just adequate.

The claims for the prilled proprietary compound fertiliser A, particularly the steadier and more even release of nitrogen, seem to possess some substance, although this characteristic proved in fact to be a positive disadvantage under the conditions of this trial, since leaf grades for treatments A1 and A1½ were significantly poorer than for the equivalent mechanical mixture D1 and D1½. Probably the slower and more even release of N from compound A operated later in the crop life than mixture D and more adversely affected ripening. Leaf N:K ratios before and after rain in Table IV lend support to this hypothesis.

In the literature it is frequently recommended that any practice that might leave active residual nitrogen late in the crop life, whether by slow acting manures or by late top dressing, interferes with ripening and lowers quality. Therefore, it would seem safer to use mechanical mixtures of straight ingredients rather than slower acting prilled compounds under our conditions and avoid this risk.

Conclusions

Satisfactory crops of Virginian tobacco cannot be grown without manuring.

Fertilisers with $N:P_2O_5:K_2O$ ratios 1:1:1.6 did not prove suitable. Applied in amounts sufficient to ensure good growth, leaf quality will usually be poor, ripening green and curing dark brown.

Excessive proportion of K_2O apparently had an adverse effect on yield of leaf, without sufficient compensating effect on grade. K_2O should apparently comprise less than 50% of the total nutrients in the fertiliser.

The $N:P_2O_5$ ratio in the fertiliser exerted the greatest influence on leaf grade in this trial. This ratio should apparently be wider than 1:2.

Little can be said about the effect on leaf grade of the interaction between fertiliser nutrient ratio and quantity applied from the scant

results of this trial, but the adverse effect on leaf grade of high N, low P_2O_5 fertiliser D, appeared at the higher level of application. In reverse, the higher levels of the low N, high K_2O fertiliser C and of the medium N, medium K_2O fertiliser B, further improved leaf grade.

No advantage was discovered by using a prilled compound fertiliser as compared to a mechanical mixture of similar major nutrient ratio, on the contrary, the latter produced leaf of higher grade. For the present, therefore, straight mixtures are to be preferred.

These conclusions are of necessity tentative but it is noteworthy that the results are in line with findings from previous fertiliser research on Virginian tobacco and in other fields on Malayan soils. Major phosphate deficiency is a proven limiting factor in Malaya on many crops. The effect during growth on leaf colour of the $N:P_2O_5$ ratio in the fertiliser is a matter of common observation on wet padi for example. Low N high P_2O_5 fertilisers giving pale green or yellowish leaf colour even in cases where the total N applied is quite high; high N low P_2O_5 fertilisers giving dark green or blue green colour even in cases where the total N applied is quite low. Similarly, excepting very sandy soils, numerous attempts, on many crops, have failed to demonstrate clear growth responses to K_2O applications. Some cases where K_2O applications are suspected to have reduced vegetative growth have occurred in rubber. Taken altogether, these pointers all support the trial conclusions.

Parallel with this trial, approximately 50 acres of field observations were grown throughout the Kota Bharu district by a local tobacco company. Fertiliser of $N:P_2O_5:K_2O$ ratio 1:1:1.6 was mainly used but some approximating to the ratio 1:4.3:3.9, with the addition of 2% MgO were tried. The best leaf, and of quite good colour, was produced by the latter on soils similar to Melor.

Recommendations

Further investigation is essential to check the trends brought out by this exploratory trial, in particular to test major nutrient ratios from 1:3:2 to 1:5:4. In addition, in view of other field observations made during 1960, and of the frequent deficiency of magnesium found in other crops in Kelantan, the effect of the minor element magnesium should be investigated.

Acknowledgements

I acknowledge with thanks the assistance of Inche Nik Mustapha bin Nik Yusoff, Junior Agricultural Assistant in-charge Dry Padi Experiment Station, Melor and Inche Abdul Majid bin Ismail, Mandor for their unsparing diligence in the day to day growing of the crop, without which this trial would not have been possible and thank

Mr. L. C. Been of the Malayan Tobacco Company for his invaluable assistance and advice throughout the experiment. Lastly, but by no means the least thanks to Mr. I, Watson, Statistician of the Division of Agriculture, Ministry of Agriculture and Co-operatives, Federation of Malaya, for his painstaking task of checking the statistical calculations and conclusions and the draft of this article.

References

(1) Garner, W.W. (1951): "The Production of Tobacco" Revised 1st Edition, Blackeston New York.

(2) Jolly, J.W. (1933): "Tobacco Experiments at Singapore" *Malayan Agricultural Journal,* Volume 21, p. 3,

(3) Marsh, T.D., and Kanagaratnam, N. (1932): "The Cultivation of Tobacco in Malaya", *Malayan Agricultural Journal,* Volume 20, p. 557.

(4) Marsh, T.D. (1937): "Tobacco Experiments at the Central Experiment Station, Serdang, 1933—35," *Malayan Agricultural Journal,* Volume 25, p. 318.

Table I

Fertiliser Treatments

Mixture	Nutrient Ratio N : P_2O_5 : K_2O	Nutrients per plant of the mixture N	P_2O_5	K_2O	Total Nutrients Per Plant	Total Fertiliser Per Plant	Constituents
		gms.			gms.	gms.	
A1	1 : 1 : 1.6	1.44	1.44	2.28	5.16	12	Prilled compound tobacco fertiliser, analysis 12:12:19.
B1	1 : 2 : 1.6	1.13	2.25	1.78	5.16	15.63	15 parts of prilled compound tobacco fertiliser. 10 parts of Single Superphosphate, (18% P_2O_5).
C1	1 : 2 : 3	.86	1.72	2.58	5.16	14.48	15 parts of prilled compound tobacco fertiliser. 10 parts of Superphosphate (18% P_2O_5). 5.31 parts of Sulphate of Potash, (48% K_2O).
D1	1 : 1 : 1.6	1.44	1.44	2.28	5.16	19.6	5.71 parts Sulphate of Ammonia, (21% N). 6.67 parts Superphosphate, (18% P_2O_5). 3.96 parts Sulphate of Potash, (48% K_2O).
A1½	As in mixture A1	2.16	2.16	3.42	7.74	18	As in mixture A1.
B1½	As in mixture B1	1.69	3.38	2.67	7.74	23.45	As in mixture B1.
C1½	As in mixture C1	1.29	2.58	3.87	7.74	21.72	As in mixture C1.
D1½	As in mixture D1	2.16	2.16	3.42	7.74	29.4	As in mixture D1.
CONTROL	Nil	0	0	0	Nil	Nil	No Fertiliser.

NOTE: All treatments including the Control received a basal dressing of 2 pints of well rotted cattle manure per plant before planting.

TABLE II

Results of soil analysis, Dry Padi Experiment Station, Melor (40 (acres)
149 samples of the top 6 inches of soil.

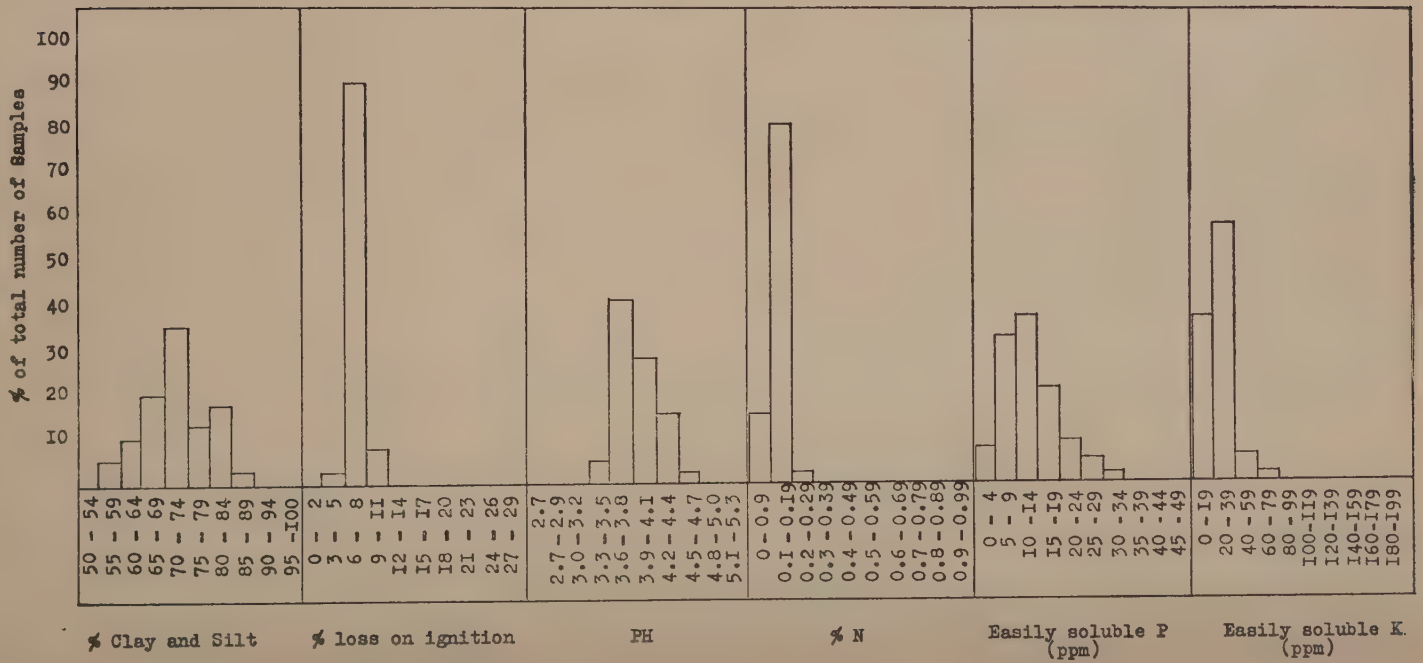


Table III

Daily Rainfall, February to May, 1960, with dates of Planting and Harvesting the Tobacco Crop. Dry Padi Experiment Station, Melor.

Day	Inches	Day	Inches	Day	Inches	Day	Inches	Day	Inches
February		25	—	23	—	17 3rd plucking		8	—
1	—	26	—	24	—	17	—	6	—
2	—	27	—	25	—	18	—	10 7th plucking	
3	—	28	—	26 Harvest commenced		19	—	10	—
4 Planting commenced		29	—	26	—	20	—	11	—
4	—	March		27	—	21 4th plucking		12	.85
5	.41	1	—	28	—	21	—	13	—
6	.14	2	—	29	—	22	—	14	—
7	—	3	—	30	—	23	—	15	1.12
8	—	4	—	31 2nd plucking		24 5th plucking		16	.16
9	—	5	—	31	—	24	—	17	.47
10	—	6	—	April		25	—	18	—
11	—	7	—	1	—	26	—	19	—
12	—	8	—	2	—	27	—	20	.16
13	.56	9	—	3	.64	28	—	21	—
14	.61	10	—	4	.38	29	.46	22	.18
15	.02	11	—	5	.71	30	—	23 8th plucking	
16 Planting completed		12	—	6	.88	May		23	—
16	.06	13	—	7	.17	1 6th plucking		24	.05
17	—	14	—	8	1.2	1	.66	25	—
18	—	15	—	9	—	3	—	26	—
19	.19	16	—	10	—	3	.03	27	—
20	1.57	17	—	11	—	4	.02	28	—
21	—	18	—	12	—	5	—	29	.05
22	—	19	—	13	—	6	1.03	30 Last plucking	
23	—	20	—	14	—	7	—	30	.64
24	—	21	—	15	—			31	.85
		22	—	16	—				

Monthly totals— February 3.56 inches. March Nil. April 4.44 inches. May 6.72 inches.

Table IV

% N, % K and N/K ratio in representative samples of cured tobacco leaf harvested before and after rain. (Results expressed on oven dry basis and placed in order of N/K ratio).

Harvested before rain (10% of the crop)				Harvested after rain (90% of the crop)				Combined	
Treatments	% N	% K	N/K	Treatments	% N	% K	N/K	Treatments	N/K
C1	1.89	4.94	.382	C1½	2.22	4.74	.468	C1	.438
CON	1.80	4.43	.406	C1	2.38	4.83	.493	C1½	.446
C1½	2.14	5.03	.425	B1½	2.14	4.20	.510	CON	.476
B1	2.32	5.45	.426	D1	2.13	4.04	.527	B1	.499
A1	2.37	4.94	.480	CON	2.37	4.34	.546	B1½	.519
B1½	2.46	4.84	.509	B1	2.66	4.64	.573	A1	.549
D1½	2.61	4.86	.535	D1½	2.78	4.65	.598	D1½	.566
A1½	2.67	4.81	.555	A1	2.49	4.03	.618	D1	.568
D1	2.63	4.32	.609	A1½	3.23	4.19	.771	A1½	.668
Mean	2.32	4.85	.481	Mean	2.49	4.41	.567	Mean	.525

Table V

SUMMARY OF RESULTS

Yield of Green Leaf

in Kg. per acre

Level of Fertiliser	Type of Fertiliser Mixture				Mean
	A	B	C	D	
0			1285		1285
1	2184	2124	1925	2172	2101
1½	2484	2268	1936	2264	2238
			(±93.53)		
G. mean					2071

Grade of Leaf

in cents per Kg.

Level of Fertiliser	Type of Fertiliser Mixture				Mean
	A	B	C	D	
0			35.58		35.58
1	36.34	39.22	38.60	38.99	38.29
1½	35.73	40.03	40.49	37.07	38.33
			(±0.4348)		
G. mean					38.00

Gross Income Realized

Dollars per acre

Level of Fertiliser	Type of Fertiliser Mixture				Mean
	A	B	C	D	
0			455		
1	789	829	739	849	801
1½	885	906	778	837	851
			(±33.55)		
G. mean					785

UPTAKE OF NUTRIENTS BY PADI VARIETY PEBIFUN

BY

K. KANAPATHY, *Soil Scientist,* and S. THAMBOO, *Asst. Research Officer.*

Introduction

In the past few years there has been a steady increase in the use of fertilisers by Malayan padi farmers. At the same time double cropping has increased in popularity wherever irrigation water is available. The variety generally used during the off-season is PeBiFun, This variety is non-photo-periodic, that is, it will flower at any time of the year as flowering is not dependent on day length. It also has the further advantage, over most other varieties in Malaya, of a short maturation period, 110-120 days from sowing to harvest. Since this variety is popular with farmers it was considered necessary to obtain information regarding its nutrient requirement and uptake in order to be able to recommend the type, quantity and timing of fertiliser applications. With this objective, an experiment was conducted in pots in the padi cage at Kuala Lumpur to ascertain the nutrient content of the padi plants at various stages of growth throughout the life of the plants.

Materials and Methods

32 glazed earthenware pots 10.5 inches internal diameter and 12 inches high (about 3 gallon capacity) were filled to about 4 inches from the top with 10 kg. (22.4 lbs.) of soil. This soil was the top 3 to 4 inches collected from the Soils/Water Research Station at Tanjong Karang. The same type of soil exists in Sekinchan and other areas adjacent to Tanjong Karang and is well known for its high yields of padi. The soil was dried and passed through a half inch sieve before use.

Selection of Seed

Padi seeds were salt separated and the good seeds were sown in pots containing the same type of soil. Five days before transplanting the glazed earthenware pots of soil were filled with water and two seedlings were transplanted to form one hill or clump in the centre of the pot. The seedlings were 26 days old at the time of transplanting (9th July).

Growth and Method of Sampling

The seedlings established very rapidly and tillering began when the plants were about 12 days old. By the 4th of August, that is 26 days after transplanting, many of the pots had more than 20 tillers and the first sampling was carried out.

Table

Index No.	Days from Trans-planting	Pot Nos.	Dry Weight in gms.	Dry Weight per hill	No. of tillers per hill	On Dry Matter Basis							Uptake in milligrams Per Hill					
						% N	% Ash	% P	% K	% Ca	% Mg	% Mn	N	P	K	Ca	Mg	Mn
1	Seedling	Nursery	7.0 (17)	0.82	—	2.56	12.96	.300	3.48	.210	.290	.031	21	2.5	29	1.7	2.4	.25
2	26	1, 9	20.5	10.25	21.5	3.42	13.50	.404	3.84	.223	.223	.028	351	41	394	23	23	2.9
3	26	3, 19	18.5	9.25	21.5	3.08	13.18	.392	3.79	.219	.223	.027	285	36	351	20	21	2.5
4	35	5, 34	53.5	26.75	34.5	2.52	13.48	.352	3.74	.235	.221	.016	674	94	1001	63	59	4.3
5	35	8, 20	47.0	23.50	34.5	2.25	12.44	.325	3.41	.229	.194	.022	529	76	801	54	46	5.2
6	46	2, 4, 10	152.0	50.7	35.3	1.28	11.98	.276	2.95	.241	.210	.020	649	140	1495	122	106	10.1
7	46	6, 7, 32	172.0	57.3	35.3	1.52	11.90	.269	2.77	.245	.200	.020	872	154	1588	141	115	11.5
8	57	11, 14	184.5	92.25	34.5	0.95	10.08	.242	2.10	.212	.187	.021	876	223	1937	196	173	19.4
9	57	12, 16	201.0	100.5	34.0	1.05	10.32	.245	2.08	.214	.199	.020	1103	246	2090	215	200	20.2
10	64 (F)	22, 27	234.0	117.0	34.0	0.86	8.90	.231	1.71	.183	.190	.015	1006	270	2001	214	223	17.6
11	64 (F)	13, 15	230.5	115.25	34.0	0.91	8.80	.227	1.81	.215	.183	.014	1049	262	2086	248	211	16.1
12	78	18, 30	364.5	182.25	34.0	0.67	8.56	.198	1.23	.166	.160	.015	1221	361	2242	303	292	27.3
13	78	24, 31	361.0	180.5	34.5	0.68	8.76	.194	1.41	.167	.160	.014	1227	350	2545	301	289	25.3
14	95	17, 26, 28	250.0	83.3	35.7	0.44	12.24	.091	2.00	.318	.209	.021	367	76	1667	265	174	17.5
15	95	21, 29, 33	245.0	81.7	34.7	0.35	13.28	.073	1.94	.365	.219	.024	286	60	1584	298	179	19.6
					No. of Ears p/h.	GRAIN												
14	95	17, 26, 28	336.5	112.2	34.3	1.02	4.58	.274	.33	.038	.126	.003	1142	307	369	43	141	3.4
15	95	21, 29, 33	326.0	108.7	34.0	1.05	4.50	.286	.33	.034	.123	.003	1141	311	357	37	134	3.3

(F) Flowering.

On sampling, the number of tillers in each pot was counted and the average number of tillers per pot was calculated. Two or three pots were chosen, whose total number of tillers were respectively twice or three times the average number of tillers per pot. The plants in these pots were entirely removed and the base of the plant was washed before the roots were cut off so that in this experiment only the aerial portion of the plants have been taken into consideration. A duplicate sample was taken in the same way and it was found that there was fairly close agreement in the dry weight of the samples in spite of the fact that each sample consisted of only two or three clumps. Samples were taken at various stages of growth including one at heading and another with the grains at maturity.

The samples were dried in a forced draught of air at 60-70°C to determine their dry weight. After grinding in a "Christie & Norris Junior Mill", parts of the dried samples were taken for the determination of nitrogen (micro Kjeldahl method), and the rest ashed prior to phosphate, potash, calcium, mangnesium and manganese determination. The results of these analyses are given in the Table.

From the Table, it is clear that the maximum number of tillers was reached about 5 weeks after transplanting. The plants commenced flowering about 9 weeks after transplanting and the grains were fully ripe 13½ weeks after transplanting (4 months after sowing). The yield of padi (unhusked rice) was 110.4 gms. per hill from a pot of 10.5 inches in diameter. If the calculation is based on 1 square foot per hill which is the usual planting distance in the field, the equivalent yield per acre would be as high as 10,579 lbs. (1,889 gantangs).* In fact, the plants were growing under almost ideal conditions, and in spite of the high yield they did not lodge and the results are therefore of interest. The straw/grain ratio is 0.75 which is very low, denoting that the variety is very good for Malayan conditions.

The total uptake of nutrients by the plants yielding the equivalent of 1,889 gantangs per acre can be calculated from the Table as follows:

	In lbs. per acre		
	Straw	Grain	Total
Nitrogen (N)	31.26	109.40	140.66
Phosphate (P)	6.49	29.61	36.10
Potassium (K)	155.80	34.77	190.53
Calcium (Ca)	26.98	3.81	30.79
Magnuesium (Mg)	16.91	13.18	30.09
Manganese (Mn)	1.78	0.32	2.10

The table also shows that the total nutrient content of the seedlings at planting is relatively insignificant compared with their content at

* In practice the yield would be slightly less due to mutual shading and competition between plants.

maturity. The young seedlings contained less than 2 per cent of the final nitrogen and potassium content and less than one per cent of the phosphorus, calcium and magnesium content at maturity. It is not surprising that Japanese research workers prefer a rigid, erect and slightly yellow coloured seedling somewhat deficient in nitrogen which is capable of establishing itself very rapidly after transplanting, to a large soft green seedling which is slow to recover from transplanting.

Nutrient content of the rice plant

From the Table and accompanying graphs, it may be seen that the percentage of ash and all elements, with the exception of calcium, were highest 26 days after transplanting and declined steadily as the total amount of dry matter increased. Slight symptoms of nitrogen deficiency were shown by the plants just before flowering, when the average nitrogen was 0.8 per cent. The percentages of nitrogen and phosphorus were higher in the grain than in the straw while the reverse was true for potassium, calcium, magnesium and manganese.

Uptake of Nutrients

The rates of growth and uptake of nutrients were calculated by estimating the average increase in dry matter and nutrient content at intervals of 10 days. From the graph showing the rate of growth it is clear that the rate increased steadily from about one week after transplanting and reached a peak at the time of flowering. At this stage, the stalk and leaves accumulated dry matter at the rate of 4 to 5 gms. per day. After this period of intense growth the rate fell very rapidly towards the zero just before harvest.

The rate of nitrogen accumulation by the aerial portions of the plant did not follow the same curve as growth rate. There is a suggestion that there were many variations in the rate of accumulation. As shown in the graph, the rate of absorption and accumulation increased very rapidly after transplanting and reached a high rate in about 25 days. This was a period of very active tillering—the maximum number was produced within 35 days. After this period, the rate of nitrogen accumulation seemed to fall. However, nitrogen continued to be taken up quite fast even after flowering.

The rate at which the plant absorbed phosphate was found to be somewhat similar to that for nitrogen except that there was a delay in reaching a high rate. The peak was not reached until about 45 days after transplanting. Phosphate was also taken up after flowering.

On the other hand, the rate of potash accumulation was quite different from that of nitrogen and phosphorus. There was a steady rise to the peak at about 35 days, when the maximum number of tillers had been formed, and then there was a steady fall to the low rate at

flowering. There was then little accumulation of potash and, in fact, some seemed to be lost possibly due to leaching from the leaves by rain so that the rate of accumulation was negative.

Discussions

The reason for the accumulation of nitrogen and phosphate in considerable amounts even after flowering is possibly due to the fact that these two elements are required in abundance to fill the grain. On the other hand the potash requirement of the grain is low and adequate quantities can usually be translocated from the stalk and leaves to the panicle.

Since nitrogen is easily lost under water logged conditions, it should be applied just before the period when the rate of accumulation in the plant is high. The initial application should be given just before transplanting; it must be well dug into the soil so that it will be available 15 to 20 days later. Nitrogen could possibly also be applied 10 to 14 days after transplanting and trampled in although there is some risk of losses through oxidation and reduction. The next application, according to the rate of accumulation of nitrogen, should be just before flowering, so that after flowering the grains will be filled. However, weather conditions as well as the decomposition of organic matter or off-season vegetation must be taken into account, since it is well known that during cloudy weather plants require less nitrogen and more potash. It is not certain that nitrogen applied a few weeks before flowering will be accumulated and then translocated to the grains. The large amount of nitrogen taken up by the plants after flowering in this experiment might have been because they showed signs of nitrogen deficiency just before flowering. One thing is clear, and that is that nitrogen can be taken up in considerable quantities, at a fairly high rate, even after flowering.

Since the phosphate and nitrogen curves for rate of absorbtion are similar it is likely that phosphate could also be applied in split dressings. However, this is unnecessary as under water logged conditions there is neither any loss of phosphate due to fixation (1) or due to leaching. It is reported that, in certain parts of Malaya, padi planters prefer to top dress their fields with super phosphate. This is not by any means a wasteful process since considerable amounts of phosphate are taken up after flowering.

With regard to potash, it is clear that most of it can be taken up before flowering. The rate of potash uptake is low after flowering since only very small quantities of this element are transferred to the grain. The strength of the straw is supposed to depend partly on the potash content. Potash fertilisers are best given just before transplanting. Since most Malayan padi soils are either clay soils or heavy clay soils, potash is not easily leached and lost in the drainage water.

Summary

The growth and uptake of nutrients by the rice plant, variety PeBiFun, was determined in a pot experiment.

The variety PeBiFun was found to produce the maximum number of tillers within 5 weeks of transplanting, and at this time most nutrients were taken up at a high rate.

Very large quantities of nutrients have to be taken up if the plant is to produce high yields of grain.

The percentage nutrient content (on dry matter) was highest at the early stages of growth, the only exception being calcium.

Considerable amounts of nitrogen and phosphate were taken up even after flowering.

The amount of potash taken up after flowering was small.

Even on a very fertile soil there were indications of nitrogen deficiency just before heading. For this reason a top dressing of nitrogen about two weeks before heading is advocated.

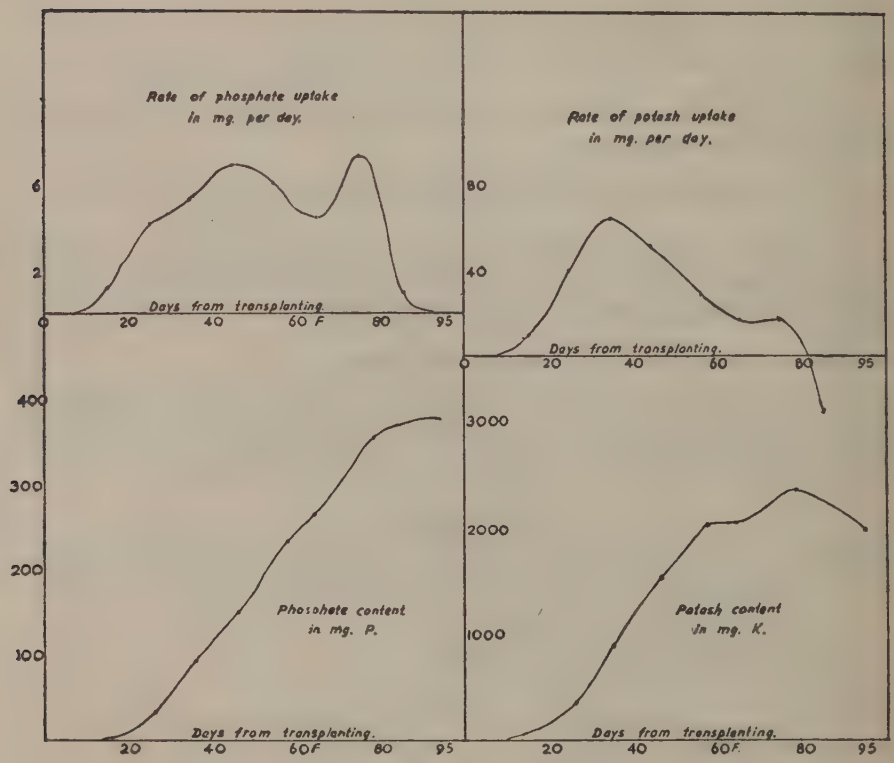
Acknowledgements

The authors wish to acknowledge the assistance of Phillip de Souza is carrying out the analyses of plants and Messrs. Abu Bakar bin Talib and S. Sebastian in helping with the pot experiment.

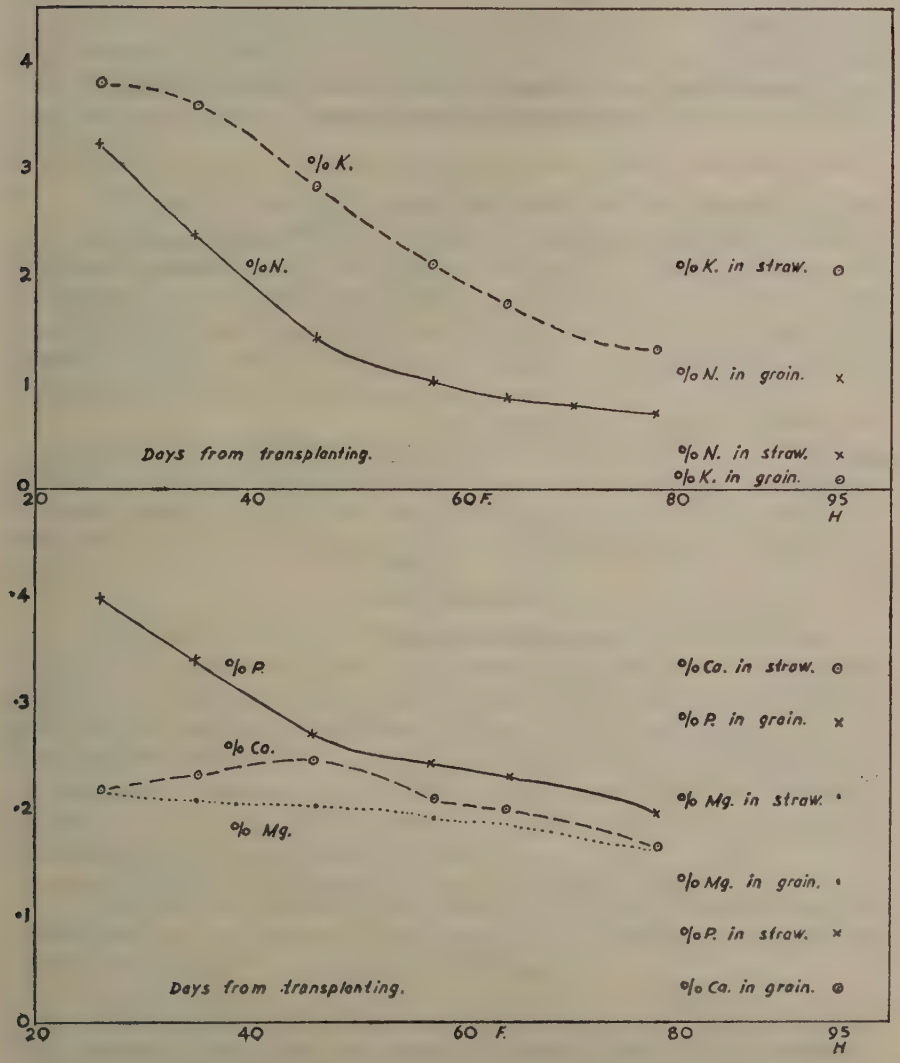
Reference

Islam, M.A. and M.A. Elahi (1954)—"Reversion of Ferric Iron to Ferrous Iron under Water Logged Conditions and its Relations to oAvailable Phosphorus".
J. of Ag. Sci., 45, Oct., 1954.

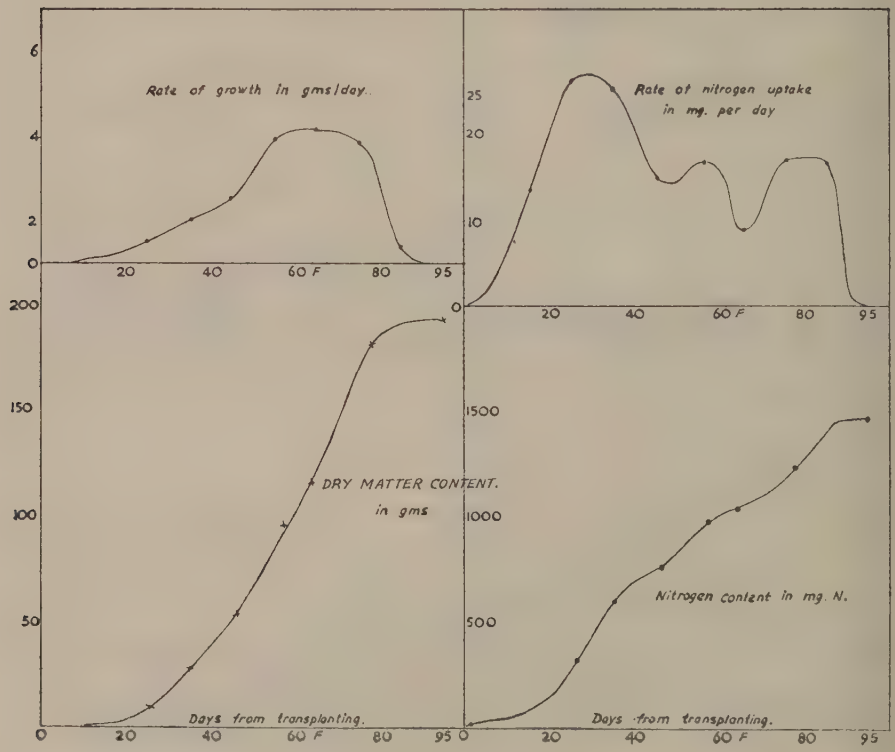
Graph showing the Rate of Uptake of Phosphate and Potash and their Relative Content in the Padi Plant.



Graph showing Percentage Content of Nutrients with Days from Transplanting.



Graph showing Rate of Growth in Relation to Dry Matter Content and Rate of Nitrogen Uptake.



VARIETY TRIALS OF SEEDLING CACAO IN MALAYA

BY

A. V. HADDON,

(*Senior Botanist*).

Introduction

In 1948 the Department of Agriculture placed cacao high on the list of crops to be considered as an alternative to rubber (2). By 1953 there was some clear evidence that it was likely to prove a profitable crop and the large scale planting of seedlings began. Experiments on field cultivation, although not complete at that time, clearly demonstrated that very healthy young trees could be grown from basketted seedlings planted under thinned jungle shade on certain soils of the East Coast Region.(1).

The type of planting material had been carefully considered from the start (17) and in 1953 Rosenquist was able to write "the West African *Amelonado* variety promises to be as successful in Malaya, within the limitations of our climate, soils, etc., as it has been in West Africa. It is recommended as the most promising variety for commercial planting in Malaya, and it seems certain that no superior variety or clone will be developed in Malaya for at least five years" (18).

Now that considerably more than five years have passed, this article is intended to record the progress made towards producing a superior variety and to draw attention to a few of the factors which have been found to influence the yield of seedlings under local conditions.

Cacao die-back

It must be made clear that at present cacao is not recommended as a crop to farmers anywhere in Malaya because of the widespread occurrence of *die-back*. This disease may be due to either a mineral nutrition imbalance or a pathogen or, most likely, a combination of both. It is even possible that the low level of sunlight during the monsoon should be considered. Symptoms similar to *die-back* in other countries have been caused by the attack of certain insect pests and fungal diseases but these do not appear to be the cause in Malaya.

Hypotheses attempting to explain the disease in terms of soil acidity and low base status do not account for the relatively helthy growth shown before 1954 by cacao trees of all ages.

In this article it will be shown that the hybrid varieties under trial generally show some tolerance of die-back but none is immune.

PART ONE
Selection and Breeding
Amelonado versus Trinitario

Within three years of importing the first *Amelonado* seed it was clearly established that this variety was superior to the local Malayan type of *Trinitario*. In an earlier article (18), Rosenquist has described how eight trials planted throughout Malaya showed the *Amelonado* consistently yielded more than seedlings from the best local clones. Of these eight trials only the one at the Federal Experiment Station, Serdang, was kept going after 1954.

Amelonado versus Malayan Trinitario.

This trial (C.5) was planted in April, 1950, in the form of a randomised block with three basic treatments or varieties. Treatment A was made up from 210 *Amelonado* seedlings grown directly from imported seed. Treatment B included two different progenies from the selected *near-Criollo* clone 021 (S.15) and treatment C was comprised of five different progenies, all of a distinctly *Forastero* type.

Treatment A. Amelonado seedlings (Cross number: 201).

Treatment B. Near-Criollo seedlings (Cross numbers: 114 & 115).

Treatment C: Forastero seedlings (Cross numbers: 100, 116, 117, 118 & 120).

Vegetative Vigour

Apart from one plot of Amelonado growing in a particularly fertile part of the field, the two progenies of clone 021 (Treatment B) grew most vigorously from the outset. (Table 13).* In later years, as their vigour enabled them to make repeated recoveries from successive attacks of *die-back*, the trees took on a characteristic appearance with very many small branches.

Yield

Even when it is assumed that the rate of recovery of dry cocoa from fresh beans was the same for all varieties (40%), the *Amelonado* seedlings yielded the most.

However, this superiority was less marked in the second and third years of bearing and disappeared in the fourth year (Table 12). There can be little doubt that the *Amelonado* was severely affected by die-back as it aged but the yield of 500 lbs./acre dry beans from the *near-Criollo* progenies, in their 7th year from planting, indicates some tolerance of the adverse conditions.

* Tables 12 to 34 are all together at the end of this article.

Pod and bean quality

Bearing in mind that one of the *Amelonado* plots was very favourably sited, this variety might not have been so much preferred if the quality of the pods from treatment B had been better. As the name of this treatment implies, the pods from the *near-Criollo* plots were large, red and warty. They contained, on the average, about 120 gms. of wet cocoa and the fresh bean weight was about 4 gms. per bean. Unfortunately, they also contained a large proportion of *flat* undeveloped beans and even the good beans showed an excessive loss in wheight after fermentation and drying (Recovery Rate between 28-33%). Their actual yield was therefore, in fact, rather less than the calculated figure given in Table 12.*

It was discovered that virtually all of the near-criollo seedlings were self-incompatible (clone 021 is self-incompatible) but this is unlikely to be the reason for the high percentage of flat beans per pod since cross-pollination seems to be quite adequate at Serdang (*see* Part II).

Amelonado versus Indonesian Trinitario.

In 1950, seed from seven of the best cacao clones at Bogor, Indonesia, were brought to Serdang, Malaya. Five progenies survived in sufficient numbers to be planted in a formal trial with *Amelonado* seed which had been obtained, at about the same time, from Macassar in the Celebes Islands. The other two progenies (forty seedlings of Dr. 38 and four of Dr. 2) were planted in plots adjacent to the trial.

This trial (C. 6), of five Indonesian *Trinitario* progenies versus Macassar *Amelonado*, was planted at Serdang in September, 1950—that is, six months after the trial containing Malayan *Trinitario* material mentioned above.

Vegetative vigour

Several of the *Trinitario* progenies and particularly Getas B, grew more vigorously than the *Amelonado* (Table 13), but the latter was most uniform, apart from variations due to soil fertility. (two rows of the *Latin Square* trial were planted along, what proved to be, a particularly fertile valley bottom).

Yield

Until *die-back* became severe, the *Amelonado* seedlings always produced more crop than any other progeny (Table 14). This is not to say that the Indonesian *Trinitario* did not yield well but the *Amelonado* was remarkably prolific. In their fourth year from planting, the 120 *Amelonado* trees yielded the equivalent of over 500 lbs. dry cocoa per acre and in their seventh year they reached 1,000 lb. This, it will be noted, was double the yield from the *Amelonado* planted six months

* Throughout this article, *pod value* refers to the mean weight of fresh beans per pod in gms. and *bean weight* refers to the mean weight of one fresh bean in gms.

earlier in trial C.5. The high yield was largely due to the high proportion of trees bearing a larg enumber of pods. (*See* Table 10 in Part II).

This, above all, was the reason why *Amelonado* continued to be recommended for commercial plantings. It was known that new and better material might be available in a few years time but there seemed to be little fault with *Amelonado** seedlings which could yield 1,000 lbs./acre even when growing on indifferent soil.

Leaf symptoms of die-back were apparent in 1957 and as the disease became more severe so did the yield fall despite all attempts to prevent it. Yield records, for the years after 1957, will not bear statistical analysis since so many trees were either dead or dying. (Figure 2).

Other *Trinitario* seedlings

West African Trinitario

In 1950/51 a collection of open-pollinated seeds was received from W.A.C.R.I.,† Ghana. The seedlings were planted under thinned secondary jungle at F.E.S., Serdang, and have come to be known collectively as *West African Trinitario* although they include a variety of types as shown in Table 15. It is unfortunate that the environment in this field proved to be unsuitable for good cacao growth although there has been relatively little *die-back*. Yields have been very poor and the considerable soil variability prevents any good comparison of progenies either with one another or with those in other fields. However, the variety T. 9 has done relatively well, in support of its reputation in Costa Rica and West Africa.

New Guinea Trinitario

Seeds from five selected clones growing at Keravat, New Guinea, were brought to Malaya in 1951. In New Guinea much of the cacao is planted under either legume shade or coconut palms and on rather alkaline soil. This may explain why the seedlings failed to grow well under thinned secondary jungle and on acid soil when they were planted in two observation blocks at Serdang (Table 16). In one clock the Keravat seedlings were planted immediately adjacent to the T.9 material, which has just been mentioned, and there is little doubt that, under such conditions, the T.9 is far superior.

Samoan Trinitario

The clone Lafi-7 originates from an old *near-Criollo* tree in Samoa which was known for its reputed resistance to Black-Pod disease,

---

* The *Amelonado* at Macassar was grown from seed imported during 1947 from Ghana. The *Amelonado* grown commercially in Malaya is only one or two generations removed from the old trees growing in the Botanic Gardens at Aburi, Ghana.

Die-back has prevented any formal comparison of the Macassar and Aburi strains as they are both very susceptible to the disease.

† The West African Cacao Research Institute.

(*Phytophthora palmivora* (5)). One pod of the original tree was sent to Malaya in 1950 and the 25 seedlings from it were planted in an observation plot at Serdang not far from the Indonesian *Trinitario*. They never grew well and only a few pods were harvested. Some of these were *near-Criollo* in appearance and contained large, white beans.

The cacao strain of *P. palmivora* has only recently appeared at Serdang and the seedling trees were not tested for resistance to the fungus. However, it should be mentioned here that young shoots and pods from clonal material of *Lafi-7* (which is still being multiplied in the Serdang bud-wood nursery) were tested for resistance to *P. palmivora* by artificial inoculation and found to be just as susceptible as *Amelonado*.

Upper Amazon Seedlings

The original (Po) *Upper Amozon* clones in Trinidad are descended from trees growing near the banks of the Upper Amazon river and its tributaries and they are named after the location in which they were found by Pound (16). In 1945, Posnette planted seed, in the Introductions Area of the West African Cacao Research Institute, Ghana, which had been collected from the Trinidad Upper Amazon clones (11). The open-pollinated seed which reached Malaya in 1951 was taken from trees growing in the WACRI Introductions Area. Thiry-nine seedlings were raised from this introduction and they were planted in isolation from other cacao at F.E.S. Serdang. (Pedigree details in Table 17).

It is a little unfortunate that there are only seven seedlings of progeny T.63 to represent the ten "approved" F2 seed lines which were subsequently distributed by WACRI to the Ghana Department of Agriculture (5). However, the more recent arrival in Malaya of the *Upper Amazon* (Po) clones from Trinidad makes this deficiency less serious.

Since the seed was open pollinated, it is not surprising that the Serdang seedlings include segregants from the true *Upper Amazon* phenotype. There are, for instance, seven trees which have *red-axil-spot*—a characteristic atypical of *Upper Amazon* trees.

The seedlings were planted in isolation in order that the plot could be used as a seed garden. This has proved worthwhile but it delayed any really valid comparison of their performance with that of other varieties. In Table 1, the mean yields of *Amelonado* growing in three widely separated fields at Serdang are compared with early yields from the *Upper Amazon* plot at equivalent ages. There is no doubt that the early vegetative vigour of the *Upper Amazon* plot is associated with early bearing and the temporary drop in yield in 1958 was probably due more to incipient *die-back* than to physiological exhaustion of the trees. (*See* also Fig. 1).

Table 1
Accumulated yield of dry cocoa (lbs/acre)

Variety	Serdang field number	Months from planting						
		18	24	30	36	42	48	60
Upper Amazon	50	2	82	318	383	662	878	1348
Amelonado	44A, 44B & 46A	1	2	2	22	109	291	735

The Serdang plot started to produce pods when only 18 months old and this seed was immediately sent to an estate in Trengganu for commercial planting on the so-called East Coast "cocoa soils". As more trees came into bearing it was possible to select only the best as seed mother trees. Selection was at first based upon the yield of pods, pod value and bean size of the individual Serdang trees. Since the trees showing *red-axil-spot* all yielded less than average, their seed was not used and seedlings from other trees which showed signs of *red-axil-spot* in the nursery were segregated and planted separately in the field. Subsequently, as the results of single pod fermentation tests and even progeny trials became known, the number of selected trees in the original 39 tree plot was reduced to four. These are tree number 13 (clone 404), no.18 (423), no.19 (418) and no.31 (427).

A certain amount of information is available to show how well this next generation of *Upper Amazon* seedlings have yielded in commercial plantings (*see* Tables 27-30) but the best indication of their value is given by the results of the Jerangau hybrid trials described below (Tables 18-23).

The Jerangau Hybrid Progeny Trials

Breeding Policy

In brief, the aim of the breeding programme is to produce high yielding and early bearing varieties of cacao adapted to growing under a wide range of conditions in Malaya. The cocoa from these varieties should be acceptable to the manufacturers and the dry beans should preferably be an even size with a thin tough shell and high fat content. For the time being, trees which form their first jorquette about five feet from the ground and then develop strong fruit-bearing fan banches are preferred to trees with a tendency to grow rapidly to a great height. In addition, varieties or trees which show some resistance to pests, diseases and other adverse conditions are chosen whenever possible.

It was considered that there was little to be gained by attempting to develop an improved strain of *Amelonado* (15) and, instead, the breeding work was centred around the Upper Amazon material which was showing a far greater potential value. In 1955, the original (Po)

PLATE I

F.E.S. Jerangau (1955). The pioneer cacao Station in Trengganu.

PLATE II

A two year old Amelonado seedling at Jerangau showing severe die-back. (March, 1958)

Upper Amazon clones had not yet arrived from Trinidad and the I.C.S.* clones were still in the very early stages of propagation. The first† hybrid crosses between different *Upper Amazon* trees, and between them and trees of other varieties, were therefore confined to seedlings and clones growing in trial at Serdang. (Table 2). Pollinations were done by hand but, in general, one or both of the parents of each cross was self-incompatible so that similar seed could be produced, if desirable, from an open pollinated seed garden. Apart from making numerous crosses with *Upper Amazon* clones, crosses were made between other varieties in order to explore the combining ability of clones in the following *types* of hybrid.

Table 2

The number of different progenies planted in the Jerangau hybrid trials.

Trial No. / Planting dates	C.36 Nov. 1955	C.37 May 1956	C.38 Aug. 1956	C.41 Nov. 1956	C.45 Jan. 1957	C.47 Aug. 1957	Total
(A) *S.I.Parent* x *S.I.Parent*							
Upper Amazon x Upper Amazon	0	2	10	3	2	3	20
Upper Amazon x S.I.Trinitario	3	2	0	4	4	2	15
(B) *S.I.Parent* x *S.C.Parent*							
Upper Amazon x S.C.Trinitario	0	2	0	1	0	0	3
Upper Amazon x Amelonado	1	2	0	1	0	1	5
Upper Amazon x Criollo§	1	1	1	0	1	0	4
S.I.Trinitario x Amelonado	3	1	0	0	0	1	5
S.I.Trinitario x S.C.Trinitario	2	2	2	3	5	3	17
(C) *S.C.Parent* x *S.C.Parent*							
S.C.Trinitario x Amelonado	1	0	0	1	1	2	5
S.C.Trinitario x S.C.Trinitario	2	1	0	0	0	1	4
S.C.Amelonado x S.C.Amelonado	1	1	1	1	1	1	(6)
Total	14	14	14	14	14	14	78(+6)

(S.C.=Self-compatible. S.I.=Self-incompatible.)

* I.C.S.—Imperial College Selection (Trinidad).

† Rosenquist made the very first inter-varietal hybrid crosses in Malaya in 1953. He produced a few seeds of (*Trinitario 021* x *Amelonado*) and (*Nanay 32* x *Amelonado*) and these were planted at Serdang. Although these hybrids did not actually grow or yield well they were very much superior to the *interplanted Amelonado* seedlings.
The The *Nanay 32* clonal material used here died in the basket soon after producing a few flowers.

§ The name *Criollo* is used here to describe the less vigorous strain of Malayan cacao sometimes found growing as single trees in old villages. It is self-compatible and has white beans.

Selection of Parent Clones

A complete account of the methods used for the selection of individual clones and trees at Serdang for propagation and breeding will be given in another article dealing with the cacao clonal trials. However, it should be mentioned here that the crop was recorded from more than four thousand individual seedlings and samples of at least fifteen pods from most of them were examined to determine the mean fresh bean content. The compatibility status* of a large proportion of the trees was tested by hand-pollination, and micro-fermtation tests were made on pods from all those trees which were provisionally selected. The selection standard for yield of fresh beans was expressed in terms of the accumulated mean yield from *Amelonado* trees of the same age. The standard varied between 200 per cent and 800 per cent according to the value of other selection criteria. It was found that all but a few of the high yielding trees produced beans with a dry weight greater than 1 gm. and none exceeded the standard of 14 per cent shell on bean suggested by Cope (4). It is suggested by Wadsworth (21) that the dry beans of selected clones should contain at least 60 per cent fat but this could seldom be achieved and the 53 per cent, used by Cope (4), was regarded as the minimum acceptable. Small samples of chocolate were prepared but, since there is no recognised "Malayan" flavour, selections were classified as either "good chocolate flavour" or "within the West African Amelonado range".

An abbreviated summary of the clones used for breeding is given in Table 32.

Field Trial Design

Progenies of these nine hybrid types were planted in a series of six trials at the Federal Experiment Station, Jerangau, Trengganu. This Station is sited on one of the best Malayan granitic soils and is immediately adjacent to the pioneer estate and smallholder cacao schemes.

A simplified *diallel* pattern of crossing had been planned so that a fair proportion of each hybrid type would be represented in the trials. However, pest damage to the hand pollinated pods was greater than anticipated and the trials were therefore planted with groups of 13 hybrids and a control as they became available. Reciprocal crosses of the same type of hybrid are grouped together although they retain their identity in the individual plots. Each of the six progeny trials contains control plots grown from open pollinated Serdang *Amelonado* seed. The layout and design of all six trials are based on a similar pattern. (*See* Table 18).

* A minimum of thirty flowers were hand pollinated on each tree. Pollinations were made before 11 a.m. on freshly opened but unprotected flowers. Trees on which more than 30 per cent of the flowers remained *set* after 2 weeks were classified as *self-compatible.*

PLATE III

Ground conditions on the site of hybrid progeny trial C.36 at planting.

PLATE IV

A vigorous three years old hybrid seedling in trial C.36 with the preferred height of jorquette and strong fan branches.

Vegetative vigour of the Jerangau hybrids

Until six months after planting there was little or no difference in the vigour of the various progenies. If anything, *Amelonado* tended to look the most healthy and uniform during the nursery stage. The vigorous progenies began to show up six months after planting in the field, and differences were very marked by the time the trees were one year old.

Girth measurements were taken for only three years since it was found that, with the exception of progenies in trial V, the trees with the greatest girths at one year old were still among the largest at three years. **(Tables 18-23 and Fig. 6).**

Observations were made of tree habit and shape but it was soon apparent that environment had such an influence that differences, if they existed, between different hybrid types could not be detected. Even the hypothesis that the height-to-girth ratio, of the first year's growth of the seedling stem, is a genetic characteristic was found to be untenable as more complete results were obtained.

However, taking the girth measurements of all six trials into account, it does appear that the most vigorous hybrids were produced by crossing *Upper Amazon* clones with either *Trinitario* or *local Criollo* clones. The progenies with the greatest girth at three years old in each trial are listed below.

Table 3

Trial number	Cross number	Hybrid type
I	751	Upper Amazon x Trinitario
II	754	Upper Amazon x Trinitario
III	852	Upper Amazon x Criollo
IV	758	Upper Amazon x Trinitario
V	154	Upper Amazon x Trinitario
VI	954	Trinitario x Amelonado

Some of the hybrids, which were not only vigorous but happened to be growing in a favourable site, produced a canopy so quickly that it was closed by the time the trees were little more than three years old. There is little doubt that these trees could have either been grown with far less overhead shade at this stage or spaced more widely apart.

Yield

In all trials, the first pods were produced within two years of

planting and in all cases the first trees to fruit were those with at least one *Upper Amazon* clone as a parent. Within the material under trial, the most precocious type of hybrid was obtained by crossing *Upper Amazon* clones with *local Criollo* clones (although cross no.851 was an exception). *Upper Amazon* crossed with Trinitario, and "pure" *Upper Amazon* hybrids, also came into bearing very early compared with the *Amelonado* control. (Table 18 & Fig. 7).

As the trees matured the early bearers did not all maintain their superiority—especially those which proved to have a small weight of beans per pod. However, yield results are, unfortunately, only reliable for the very widest comparisons since the degree of error* in the trials was very markedly increased by two factors. Firstly, some varieties were more affected by *die-back* than others and this created considerable "edge effects" in adjacent plots and, secondly, the trunks of large jungle trees, which had been felled just befoer the cacao was planted, began to decay and so produce marked beneficial effects on the cacao trees growing adjacent to them.

Any chance of making a really valid comparison of progenies growing in different trials was lost when the *Amelonado* control, which was supposed to provide the link between all six trials, proved to be so susceptible to *die-back* disease that many trees either became moribund or died.

The yield figure given in Tables 15-20 can therefore only be used as a guide to the potential value of the various hybrids. When they are treated as such, and due consideration has been given to planting dates and field observations, it appears fairly certain that the following sixteen crosses include the very best hybrids and that they all give a greater yield of fresh cacao than *Amelonado*.

Table 4

Cross number	Hybrid type
401, 403, 404, 407 & 419	Upper Amazon x Upper Amazon
750, 751, 754, 757 & 758	Upper Amazon x S.I.Trinitario
800	Upper Amazon x S.C.Trinitario
850 & 852	Upper Amazon x local Criollo
700	Upper Amazon x Amelonado
901	S.I.Trinitario x Amelonado
154	S.I.Trinitario x S.C.Trinitario

* In Trial I (C.36), the Coeff. of Variation for girth measurements taken after one year (1956) was 11% and this rose to 15% for the 1958 figures. For pod number, the Coeff. of Variation was 90% for the mean of three years (1958, '59 & '60) and if the statistical analyses were of any great importance it would be essential to take account of the high positive correlation between the Standard Deviation of pod numbers per plot and the mean yield for each progeny.

Pod and bean quality

The average weight of fresh beans per pod for each progeny* is given in Tables 18-23. These figures again are no more than indicative of how the progenies compare with one another and in a few cases (particularly in trial C.48) data were so few that no values are given. Taken as a whole, pod values are satisfactory even amongst those progenies producing a large number of pods. The "pure" *Upper Amazons* produced pods well up to average size and six progenies gave pods containing more than 130 gms. of fresh beans. Of course, the largest pods were produced by the "pure" *Trinitario,* with cross number 145, the progeny of two Serdang large-pod selections, being among the best. No explanation has yet been found for the increased pod value of *Amelonado* at Jerangau. At Serdang the average value is not more than 115 gms. fresh cocoa per pod but at Jerangau this has risen to about 130 gms.

It is fortunate that large bean size, although desirable is not an essential characteristic of good cocoa, because three of the highest yielding hybrids (crosses 401, 407 & 700) produce fresh beans with an average weight of slightly less than 3 gms. On the other hand, most of the other high yielders average over 3.5 gms. per bean and cross no. 850 has an average bean weight of 4 gms.

It is appreciated that records of the yield of fresh beans per pod and fresh bean weight are of little value unless the recovery rate after fermentation is also known. Attempts were made to keep the beans of individual progenies separate from one another during bulk fermentation by placing them in net bags made from synthetic fibre but results obtained in this way were inconclusive. However, it was possible to demonstrate that in these trials the recovery rate, of dry beans from fresh, is consistently higher for *Amelonado* than the majority of other varieties and that the ratio of pods to dry cocoa is approximately as follows:—

Table 5

	Amelonado	Upper Amazon sibs & hybrids	All other hybrids
No. of pods per pound of dry cocoa	10	10.9	9.5
Ratio of dry cocoa to fresh	42%	36%	36%

* In most cases the weight of beans per pod is based on the average for individual trees. When crops were heavy, the average figure per plot was recorded.

Small samples of beans from the highest yielding bybrid trees have been processed in the microfermentory (3) and chocolate made from them has been accepted as within the "West African Amelonado range" by the Department's tasting panel.

The Cacao Genetic Blocks

The Jerangau hybrid trials have in fact been more successful than anticipated. As soon as they had been planted further breeding was done in order to improve the parental stocks. Unfortunately, the three blocks of improved' material, which are described below, were planted at a time when *die-back* disease was particularly severe and some progenies were almost immediately decimated. Improvement was directed towards three major aims.

Upper Amazon backcrosses

Firstly, it was considered quite likely that the vigour of the *Upper Amazon* parent clones at Serdang might not be maintained in a further generation of out-breeding (neither the male parent nor male grand-parent of most of the Serdang U.A. trees is known). The original *Po* clones from Trinidad were just beginning to flower in the Serdang nursery and so, in order to take advantage of the selection work already done in Malaya, and yet restore some of the original vigour of the *Upper Amazons,* the Serdang selected clones were backcrossed* with *Po* clones. The progenies derived from these crosses were planted in trial with *Amelonado* control at Jerangau at 8′ x 8′ and 12′ x 12′ spacing. (Trial C.48). For some unknown reason, *die-back* was extremely severe in one of the widely spaced group of progenies and so no comparison of spacing treatments has been possible. As usual, the *Amelonado* was very much more affected by *die-back* than any of the *Upper Amazon* progenies, and even they had to be pruned very hard during the usual field "clean-up" following a severe attack. Girth and yield records are of doubtful value and perhaps the eye-scores for general health and vigour are the best guide to the comparative value of these backcross progenies. (Table 24). Taking these scores into account, and bearing in mind the results of other hybrid trials, (*see* especially Tables 29 & 30), improved clones for future breeding are most likely to be found in the following progenies.

Cross Number	Percentage
480	404 x 451 (IMC 76)
483	423 x 454 (Nanay 33)

* The term "backcross" is used very loosely and does not have the strict genetic meaning.

PLATE V

Two year old Amelonado seedlings under dwarf coconuts on Kuala Bernam Estate.

PLATE VI

One year old Amelonado under tall coconuts on Kuala Bernam Estate.

Inbred progenies

The second group of 'improved' progenies had a dual purpose. On the one hand there was a shortage of selected self-compatible clones, and it was felt that this might prove a hindrance to adequate pollination in the field. On the other hand, there was a chance to improve the vigour of hybrid progenies if their parents were deliberately inbred. It was intended that progenies should be selected from this block (C.43) not on their own performance but on the performance of their parents in the hybrid trials. The field layout was therefore not replicated and progenies were planted in twin rows of 58 plants. However, apart from being susceptible to *die-back* some of these inbred progenies have grown quite well and appear to be fairly uniform. If, for some reason, the *Upper Amazon* hybrids ever become undesirable, the best of these progenies could prove to be a useful alternative to *Amelonado*. The meagre information available from this block indicates that ICS 6 seedlings are the first to come into bearing although they do not have the greatest girth. (Table 25).

Criollo progenies

The group of *near-Criollo* progenies (C.44) was planted in order to provide a source of new clones with "improved" bean quality. The Serdang parents of these progenies were selected mainly for their *Criollo* or *near-Criollo* pod and bean characteristics. In particular, clones which were known to produce white beans, as a result of selfing during compatibility tests, were preferred. (The Tasting Panel was unable to offer any consistent comment on the comparative flavour of chocolate prepared by microfermentation from *near-Criollo* and *Amelonado* trees).

As with the inbred progenies, these seedlings were intended to be a source of new clones and they were therefore also planted in twin rows instead of replicated plots. Results (Table 26) so far indicate that there are considerable differences between progenies in their ability to recover from *die-back* but no attempt has yet been made to select either progenies or trees for quality of beans.

Hybrid seedlings planted on estates

The blocks of hybrid cacao seedlings planted on estates are only meant to make preliminary comparisons with standard *Amelonado* material and in no case are they planted in a formal replicated trial. Nevertheless these observation blocks have confirmed that *Upper Amazon* seedlings are superior in yield and vigour under a wide range of conditions* which even include plantings beneath mature tall and dwarf coconuts. (Table 31).

---

* Hybrid seedlings, grown from Serdang seed, are reported to be growing better than *Amelonado* in North Borneo.

On an estate in Trengganu, the cacao is planted under thinned jungle in conditions very similar to those on the adjacent Experiment Station. The first Upper Amazon block was planted in 1955/'56 with open pollinated unselected seed from Serdang. Because the seedlings from different mother trees were planted separately it is possible to use the planting as a rough progeny test of the mother clones. The figures in Table 27 indicate that clones 416 and 426 have passed on to their progeny the tendency to produce a large number of small pods at an early age. Apart from this, the figures confirm the considerable range of performance which is also found in the formal hybrid trials, but they do not confirm that clone 427 makes a good parent. Growing conditions in the Block are not very uniform and it would be inadvisable to attempt any further conclusions from these results.

The same caution must be used when interpreting results from the 1956/'57 area (Table 28) which was partly planted with control pollinated seed from the Serdang *Upper Amazon* plot. It is interesting to note that progenies of clones 423 and 428 are relatively high yielding, and that clone 420 is the male parent of the progeny which produced the most pods as well as the progeny which produced the least pods.

The 1957/'58 *Upper Amazon* area on Jerangau Estate was brought into bearing at the end of 1960 after suffering very severely from *die-back* soon after transplanting. No yield records are given here but it has been noted that seedlings descended from clone 452 (*Nanay 33*) were amongst the earliest to start bearing and also that the most pods have again been produced by seedlings from clone 423.

On Kuala Bernam Estate, in Perak, where observation blocks of cacao are planted under coconuts, the various *Upper Amazon* progenies have also been planted separately but only girth and not pod-number records have been collected so far. The girth records (Tables 29 & 30) indicate that the most vigorous progeny in the 1957 Block is a hybrid of U.A. clone 423 crossed with *Amelonado* and in the 1958 Block it is the cross between U.A. clones 452 and 457. Growing condition under the coconuts are fairly uniform and the planting should give some very useful information when detailed crop records are taken.

Discussion

Comparison of varieties and main types of hybrid

The cacao progeny trials have been very successful in their main aim which was to discover seedling planting material with a superior yield to *Amelonado*. This success is almost entirely due to the inherent vigour of the *Upper Amazon* variety even though the Malayan form or *genotype* is not nearly so pure as the material tested in Trinidad and

Table 6

Elite hybrid progenies

Type of hybrid	Progenies with a very high yield		Progenies with a high yield	
	Cross No.	Parent clones	Cross No.	Parent clones
Upper Amazon	419	412 x 418	404	404 x 412
crossed with	401	423 x 427	407	404 x 424
Upper Amazon	403	423 x 404		
Upper Amazon	751	303 x 427	757	700 x 428
crossed with	754	404 x 303	753	404 x 071
S.I.Trinitario	758	302 x 423	752	049 x 427
	750	423 x 071		
Upper Amazon crossed with S.C.Trinitario	800	404 x 044		
Upper Amazon crossed with Criollo	850	380 x 427	853	404 x 382
	852	423 x 382		
Upper Amazon crossed with Amelonado	700	423 x 600		
			157	757 x 103
S.I.Trinitario			149	124 x 076
crossed with			143	325 x 044
S.C.Trinitario			154	303 x 124
S.I.Trinitario crossed with Amelonado	901	301 x 600	903	049 x 600
S.C.Trinitario crossed with S.C.Trinitario			180	124 x 121
S.C.Trinitario crossed with Amelonado			954	757 x 700

West Africa. It has not been possible to completely confirm* the existence of *hybrid vigour* in crosses between different varieties, because the vigour of the *Upper Amazon* variety has an over-riding *dominant effect*, and it has not been shown that one particular *type* of cross is quite clearly superior to any other. All that can be said is that it is generally an advantage if one of the parents is an *Upper Amazon* clone and that, on the average, the type of cross *"Upper Amazon* crossed with *Malayan Criollo" is* very promising. Every type of hybrid tested at Jerangau has been found to include both very good and very poor progenies.

Comparison of individual progenies

The best or élite progenies of each type of hybrid at Jerangau are listed in Table 6.

It can be seen immediately that some parental clones are represented several times in these elite progenies and to a certain extent this must simply be due to the fact that these clones were used for breeding more frequently than others. (*See* Table 33). However, there are six parent clones which are represented by three or more élite progenies.

The clones are: 124, 303, 404, 423, 427 & 600. These six clones could be used to breed fifteen different progenies (excluding selfs and reciprocals) and, in fact, eight of the progenies are included in the Jerangau trials.

Progenies: 154, 401, 403, 700, 702, 751, 754 & 952.

It is not surprising that six of these are included in the list of elite progenies (Table 6). It is, however, interesting to note that the other two progenies (nos. 702 & 952) both have *Amelonado* as one parent, and that there does not happen to be one other case of these selected parent clones failing to combine successfully.

Comparison of individual parent clones

If *Amelonado* (Clone no.600) is omitted from further consideration, there remain five clones which can be regarded as having passed the preliminary progeny tests at Jerangau. In addition, there is a fair amount of evidence to support the inclusion of clone no. 452 (*Nanay 33*) with them (c.f. Tables 24 & 30). If we now try to examine the performance of these clones, not in combination with one another but with other clones, it is apparent that their progenies are usually high yielding

* This assertion was made by Knight and Rogers in respect of their material at WACRI (11). Table 3 above indicates that it may well be true at Jerangau. This is further supported by the vigour of the U.A. x Criollo progenies whose parental clones were geographically isolated and inbred for several generations.

Table 7

Progeny tests of some Upper Amazon parent

Trial C.38

Parent Clone Numbers	Parent Clone Numbers. 404 Cross No.	404 Girth	404 Pod No.	404 Pod value	418 Cross No.	418 Girth	418 Pod No.	418 Pod value	410 Cross No.	410 Girth	410 Pod No.	410 Pod value	415 Cross No.	415 Girth	415 Pod No.	415 Pod value
423	403	17.5	230	115	408	16.2	166	126	—				—			
424	407	17.9	189	118	406	14.2	100	130	405	17.9	157	125	—			
420	412	14.2	56	133	411	16.0	148	132	—				—			
412	404	18.4	186	119	(419 in trial C.47)				—				409	15.8	69	135
428	—				410	15.4	131	138	—				—			

Girth: (cms) at 3 years—1′ above ground.
Pod No. Mean over 3 years 1958-'60
Pod value: gms. of fresh cocoa per pod.

(e.g. Cross no.403 is the progeny of clone 423 crossed with clone 404).

Table 8

Progeny tests of some parental clones.

Female parent varieties and clone numbers		Male parent varieties and clone numbers: S.C. Trinitario 044 — Progeny/Trial No.	Pod No. index	Pod value (gms)	S.C. Trinitario 124 — Progeny/Trial No.	Pod No. index	Pod value (gms)	S.I. Trinitario 151 — Progeny/Trial No.	Pod No. index	Pod value (gms)	S.I. Trinitario 303 — Progeny/Trial No.	Pod No. index	Pod value (gms)	Upper Amazon 404 — Progeny/Trial No.	Pod No. index	Pod value (gms)	Upper Amazon 412 — Progeny/Trial No.	Pod No. index	Pod value (gms)	Upper Amazon 424 — Progeny/Trial No.	Pod No. index	Pod value (gms)	Amelonado 600 — Progeny/Trial No.	Pod No. index	Pod value (gms)
S.C.Trinitario	044					(28)	(129)	141/36	39	115	145/38	30	161		(170)	(136)	—			—			—		
	124	181/36	28	129	—			—				(104)	(114)	—			—			801/37	6	98	952/41	20	109
S.I.Trinitario	151		(39)	(115)	—			—			—			—			—			762/45	147	146		(25)	(118)
	303		(30)	(161)	154/45	104	114	—			—				(250)	(124)	—			—			—		
Upper Amazon	404	800/37	170	136	—			—			754/37	250	124	—			404/38	217	119	407/38	220	118		(29)	(138)
	412	—			—			—			—				(217)	(119)	—				(185)	(101)	703/41	24	122
	424	—				(6)	(98)		(147)	(146)	—				(220)	(118)	400/37	185	101	—			701/37	57	107
Amelonado	600	—				(20)	(109)	900/36	25	118	—			702/37	29	138		(24)	(122)		(57)	(107)	202/all	9	129

"Pod No. index" calculated from total for the 3 years, 1958-1960 and corrected for yield of each progeny in relation to others in the same trial and yield of the trial as a whole.

Numbers in brackets indicate results from the reciprocal cross. (e.g. clone 124 pollinated by clone 044 gave cross no. 181 which is planted in trial C.36).

and U.A. clone 423 is particularly good with a record of successful progeny tests on estates as well as in the Jerangau hybrid trials. However, there are exceptions and even 423 has failed to produce a good progeny when crossed with U.A. clone no. 450 (Cross no. 420 in trial C.47).

The importance of selecting a good combination* of parents for commercial hybrid seed is further demonstrated with some accuracy in Table 7 and with less precision in Table 8. The latter table should be used only to compare clones and not type of hybrid since it appears to show that, for instance, *Amelonado* crossed with *Upper Amazon* is a low yielding type of cross and does not take account of the very high yield from this type of progeny in trial C.36.

Pod and bean quality

Before the selection and breeding of hybrids proceeds any further, more attention must be paid to the quality of beans which they produce (21). The evidence available at present indicates that élite hybrids produce pods containing about 120 gms. fresh cocoa with a mean fresh bean weight about 3.3 gms. Of the two progeny-tested *Trinitario* parent clones, no. 303 is fortunately of the large-pod small-number type and no. 124 produces many small pods. The progeny tests have failed to show if one or other of these types tends to produce a higher yielding progeny when crossed with *Upper Amazon*, but there is no doubt that the large pod characteristics of clone 303 are apparent in its progenies as compared with those from clone 124.

Amongst the *Upper Amazon* parents, the slightly superior bean weight of clones 418 and 428 seems to have been inherited by their progenies.

The largest fresh beans, and greatest weight of beans per pod, are found in the two progenies of *Malayan Trinitario* clone no. 328, but they do not give a very high total yield and their Recovery Rate is likely to be low. Progenies descended from Trinidad selections also produce pods and beans well above the average size.

Conclusions and Recommendations

The Amelonado variety of cocoa is particularly susceptible to *die-back* and is not a hardy variety suitable for smallholders to plant. However, it comes true from seed and produces a readily marketable product.

Upper Amazon seedlings are generally hardy. They seem to tolerate a lack of shade and moisture better than *Amelonado* and are *usually* less susceptible to *die-back*. *Upper Amazon* seedlings appear to be more variable than *Amelonado* and there remains an element of doubt concerning the general acceptability of their cocoa to the manufacturer.

---

* The author hesitates to use the terms *specific* and *general combining ability* on the data presented here.

The highest yielding seedlings are hybrids of *Upper Amazon* crossed with some other variety. In the Jerangau hybrid progeny trials it has not been possible to select the *most* desirable hybrid progeny but eleven hybrids and five "pure" *Upper Amazons* have been provisionally selected. The cocoa quality of the hybrids is probably at least as good as that from *Upper Amazons*. If the most promising *backcross Upper Amazon* hybrid is included then the total number of potential parent clones is eighteen. This is rather a large number to combine successfully in a single seed garden and it is therefore recommended that if only one hybrid seed garden were intended to produce seed for Jerangau-type soils, then it should include the following clones. The clones to be planted in rows of three in this order:

423 : 427 : 303 :404 : 423

Crosses between adjacent rows would all give élite hybrid progenies and, since all the clones are self-incompatible, all the seed from the garden would be hybrid. The proportion of untested seed, produced by crossing between clones which are not adjacent, could be reduced by planting the clones in blocks of more than three rows but this might reduce the total crop.*

Preferably, several biclonal seed gardens instead of one polyclonal garden should be planted. The seedlings grown from such seed gardens could then be planted in separate blocks or mixed† together according to the state of knowledge at the time regarding the response of a particular hybrid to the environment in which it were to be planted. For instance, the élite hybrid cross of U.A. clone 423 with *Amelonado* (cross no. 700) has been omitted from the proposed polyclonal garden because we know that *Amelonado* crossed with U.A. clone 404 (cross no. 702) is not a successful progeny. This should not prevent the production of cross no. 700 seed from a small biclonal seed garden—especially for planting in areas known to be relatively free from *die-back* and when large bean size is not at a premium.

In order to obtain information about the range of adaptability of hybrid seedlings in widespread field plantings of hybrid seed it is most desirable that a record should be kept to show which mother clones produce the highest yielding progenies. If the beans from distinct progenies can be kept separate for assessment by the manufacturers it

---

* An isolation of 50 yards has not been sufficient to prevent cross pollination in Trinidad (5).

† Nothing yet is known about the self and cross compatibility status of the Malayan hybrid seedlings. In case a large proportion of the seedlings of one particular hybrid were all self and cross incompatible it would be safer to plant in the field a mixture of at least three unrelated hybrids. The mixture would also have a greater range of environmental adaptability.

should be possible to ensure that a standard 'Malayan flavour is maintained which conforms with trade requirements and in this way a really superior *proven* type of seed will eventually be available to the farmer.

Future selection and breeding must take into account the importance of resistance to die-back disease although it is difficult to see how this can be achieved when the real nature of the disease remains unknown. Some priority must be given to the importation of the Scavina Upper Amazon clones, as well as more seed from T 86/955 at WACRI which seems to do well in Malaya. The best hybrids from West Africa and Trinidad should be compared under various conditions with the best Jerangau hybrids if the dangers of breeding within a limited genetic stock are to be avoided.

PART TWO

Some factors affecting the yield of cacao in Malaya

Climate

It has already been established that the high humidity in Malaya neither causes excessive vegetative growth nor leads to severe attacks from *black-pod* disease. On the contrary, the equable climate at Serdang appears to encourage the development of a secondary 'peak' crop each year compared with the one end-of-year peak experienced in the monsoonal climate of Jerangau. This can be clearly seen in Figure 1. Smallholders prefer a marked 'peak' crop since they are abble to obtain enough pods from their few trees to ferment properly. Estates, of course, would prefer a steady output with no peak labour demand. The maximum crop obtained in one year from *Amelonado* is about 1,000 lbs./acre at both Serdang and Jerangau but more typical yields for each Experiment Station are given below:—

Table 9

Yield of Amelonado cacao at Serdang and Jerangau

Seed garden	Acreage	Date planted	* Estimated yield of dry cacao (lbs/acre)					
			1955	1956	1957	1958	1959	1960
Serdang (A)	1.6	1950	175	98	228	108	254	69
Jerangau (A)	1.6	1953	151	201	300	361	530	621

(* estimate based upon a conversion of 1 lb. cocoa from 10 pods)

Figure 1

Seasonal variation in the pod production, at Jerangau and Serdang, of Amelonado and Upper Amazon cacao.

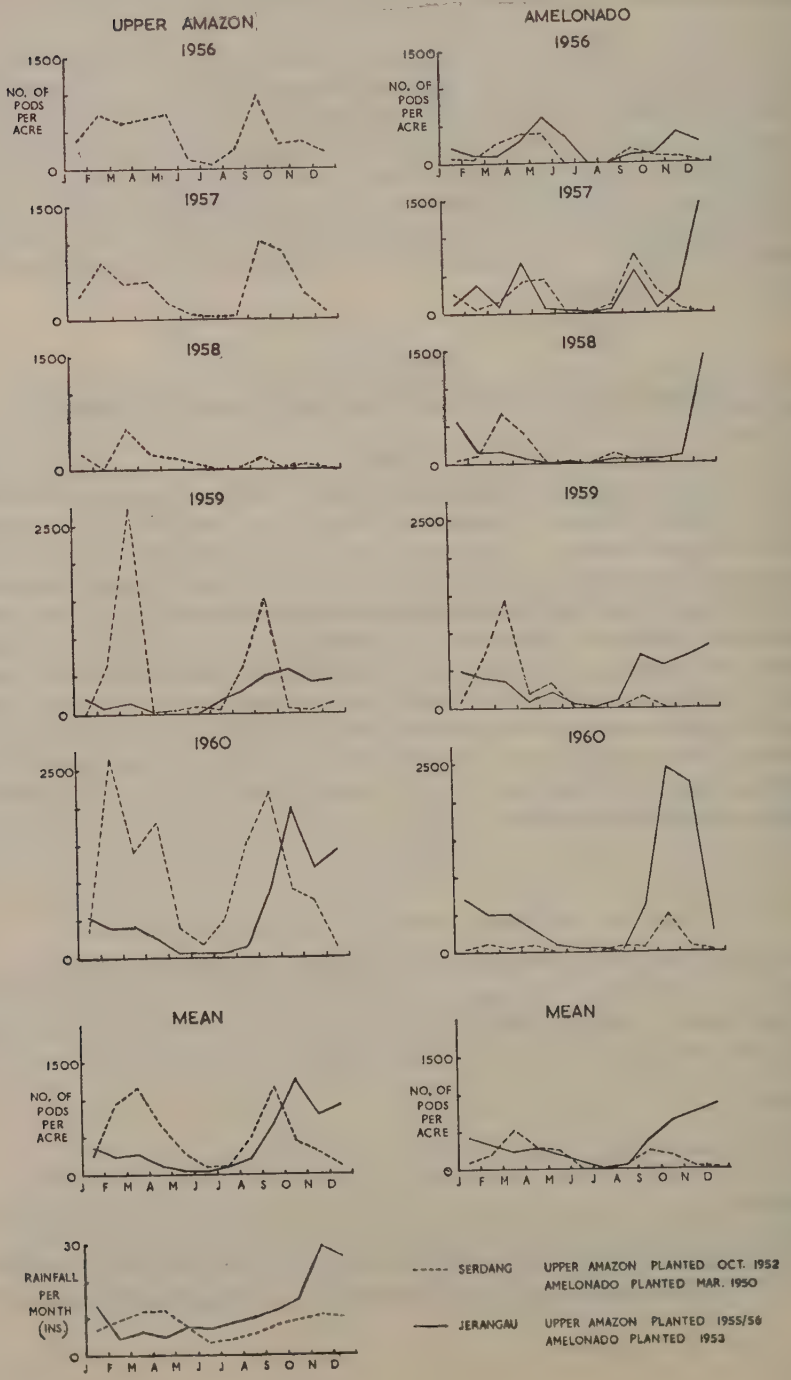
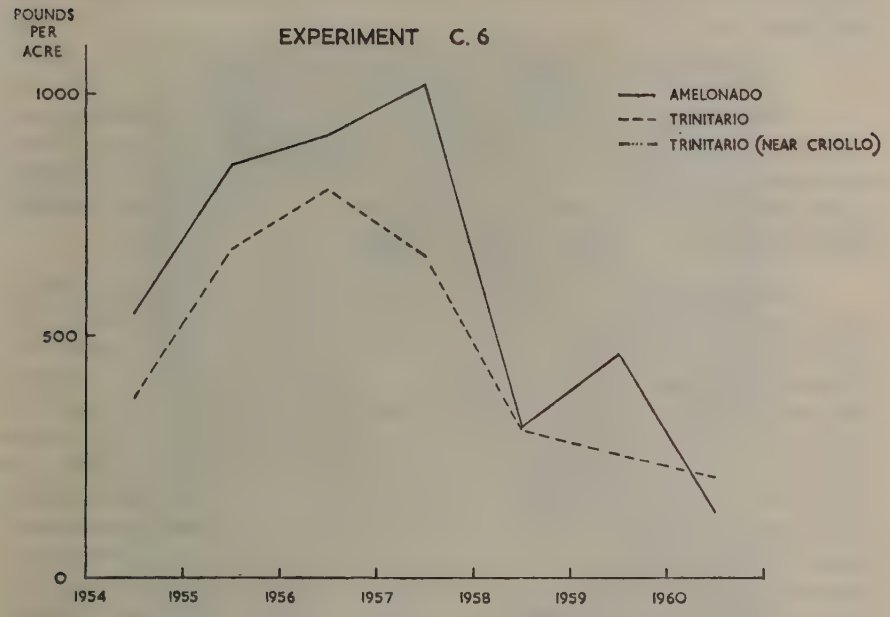
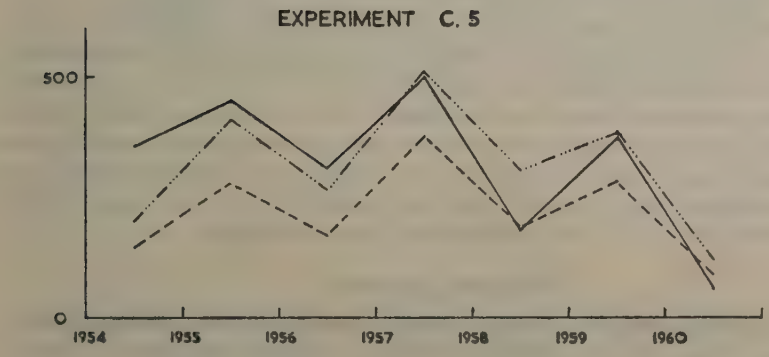


Figure 2

THE YIELD OF CACAO IN F.E.S. SERDANG
SHOWING THE EFFECT OF SEVERE DIE-BACK
AFTER ITS APPEARANCE IN 1957





Soil

Much has been written about the soil requirements of cacao. It may be that Malayan soils are generally too acid for this crop and that no crop-husbandry techniques can compensate for this, but it cannot be denied the cacao has been, and is, growing very well some times and in some places in Malaya. Yields obtained throughout the country cannot yet be correlated with soil type. In this article it is sufficient to repeat that *Amelonado* seems to be more susceptible to adverse soil conditions than other varieties.

Pests and diseases

The major pest of cacao in Malaya, the capsid sucking bug, *Helopeltis*, is easily controlled with insecticidal sprays. There is some slender evidence that a few seedlings at Serdang are relatively resistant to attack but this has not been confirmed in either clonal or progeny trials (probably because no attack has been allowed to develop).

Cacao *die-back* disease is the major factor limiting the yield of cacao in Malaya at present (Figure 2). Numerous comparisons have been made between susceptible and relatively healthy trees but it is difficult to separate causes from effects. For instance, the root systems of *Upper Amazon* trees are better developed and have a greater proportion of main, deep branch roots and so it was thought that this could be the cause of their better halth. However, in trials with *Upper Amazon* and I.C.S. clones, it has been found that buddings on *Upper Amazon* seedling root-stocks are no more healthy than buddings on *Amelonado* seedling root-stocks. In a small observation trial at Serdang it was found that vigorous hybrid root-stocks also conveyed no advantage. However, there must surely be some connection between root development and *die-back* to explain the relatively greater health of the cuttings compared with either buddings or seedlings in these same *clonal* trials.

Crop Husbandry

Observations and trials in Malaya amply confirm the results obtained in other countries (7) which show that good field management provides a nicely balanced relationship between over-head shade, mineral nutrition, planting distance and ground cover. There are many indications that *Upper Amazon* material can, and therefore should, be grown with less shade than *Amelonado*. The vigour of Upper Amazon and hybrid varieties also suggests that they should be planted more widely apart than the eight feet recommended for *Amelonado*.

Planting material

The first part of this article dealt specifically with comparisons of one type of variety or hybrid with another. Apart from this, there are more general factors which apply to all planting material.

PLATE VII

The re-occurrence of die-back after pruning back the chupon of a young Amelonado seedling.

Table 10

Variability in yield of cacao seedlings

Experiment C.6

Percentage of total crop for each variety (1957)	Minimum percentage of seedlings to produce the crop					
	Cross no.016	Cross no.017	Cross no.018	Cross no.019	Cross no.020	Amelonado 203
5	2	2	1	1	1	2
10	3	3	3	3	2	3
25	8	8	7	8	6	10
50	22	21	18	18	16	23
75	38	39	35	33	31	42
100	83	85	79	76	74	88

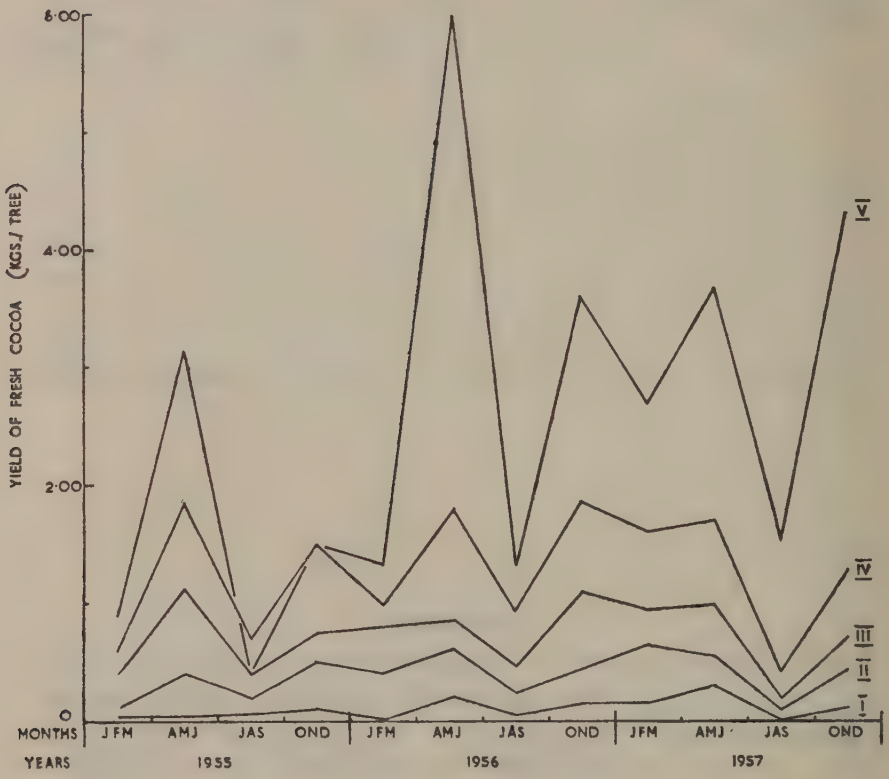
Experiment C.5

Percentage of total crop for each variety	Minimum percentage of seedlings to produce the crop		
	Treatment A (Amelonado)	Treatment B (near-Criollo)	Treatment C (Forastero)
5	1	1	1
10	3	3	2
25	9	9	8
50	22	23	20
75	42	43	39
100	87	91	95

For experiment details *see* Tables 12 and 14.

Figure 3

Seasonal variation in the yield of five classes of seedlings in experiment C.6.



Class I : trees yielding between 1% and 37% of field mean
Class II : „ „ „ 38% and 75% „ „
Class III: „ „ „ 76% and 150% „ „
Class IV: „ „ „ 151% and 300% „ „
Class V : „ „ „ 301% and 600% „ „

(Mean yield/tree=7.94 kgs)

Figure 4

Seasonal variation in the pod production of self-compatible and self-incompatible trees in experiment C.6 at F.E.S. Serdang.

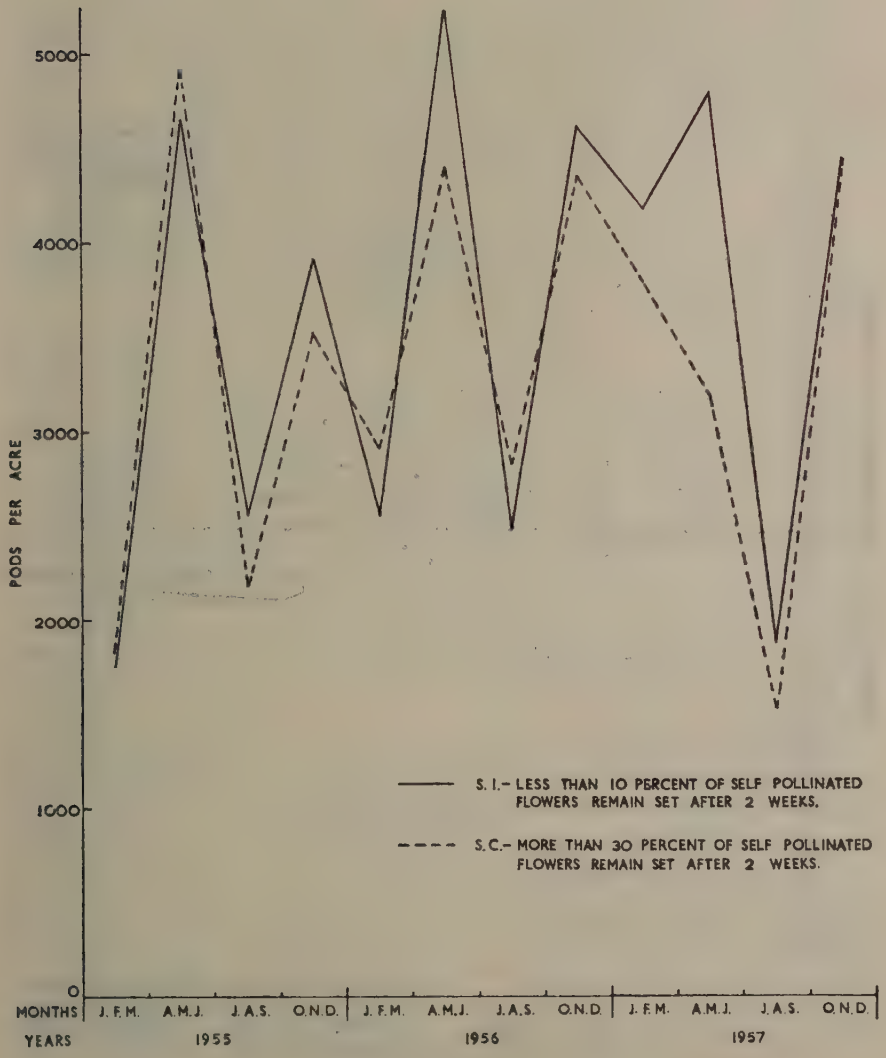
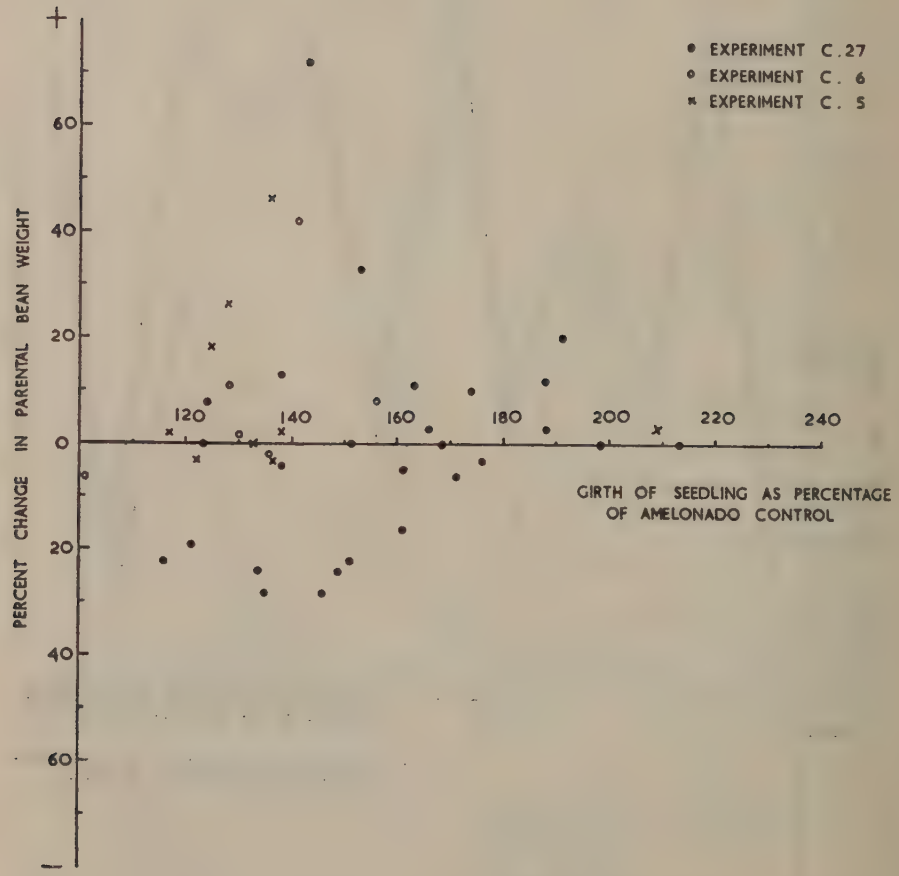


Figure 5

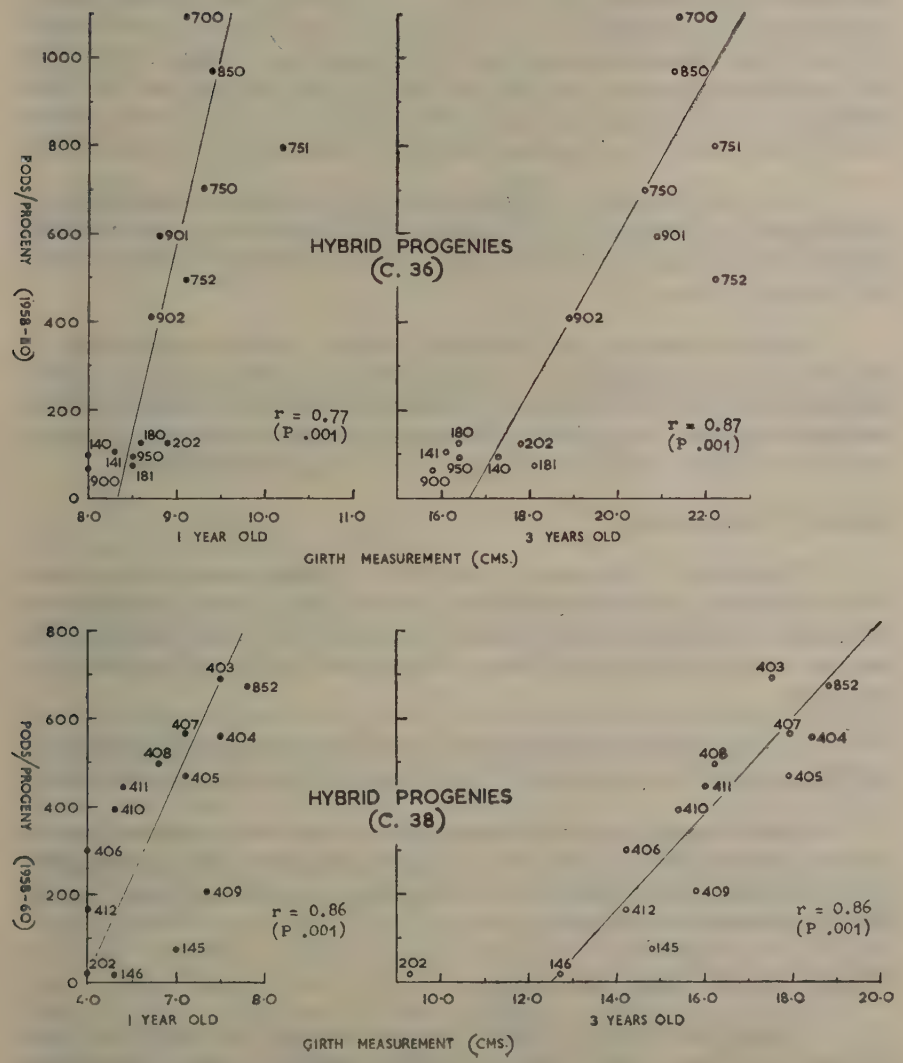
Selection for progeny vigour before seed germination.



(Hybrid beans produced in three field experiments at Serdang and planted in the Jerangau hybrid progeny trials.)

Figure 6

The Cacao tree girth-yield correlation.



GENETIC UNIFORMITY

A healthy stand of *Amelonado* seedlings provides a more uniform appearance than other types of planting material tested in Malaya. Despite this it can be expected that 50 per cent of an *Amelonado* crop will come from no more than 25 per cent of the trees and 10 per cent of the trees will bear almost no crop at all. This sort of distribution* cannot be completely avoided but it is undesirable in a field planting which should be as uniform as possible so far as yield is concerned. Table 10 indicates that seedling of progeny no. 020, in trial C.6 at Serdang, are the least desirable from this point of view with 50 per cent of the crop coming from 16 per cent of the trees and only 74 per cent of the trees in bearing.

It is interesting to confirm that the *Amelonado* population in another trial at Serdang (C.5) behaves in a very similar way although in this trial it appears that the *near-Criollo* progenies (Treatment B) are no less uniform.

While considering the variability of trees within a population, it may be noted that results from Serdang (Figure 3) show that the highest yielding trees owe their crop to a relatively high pod production all the year and especially high during the 'peak' production seasons. It is not due to any special ability to produce a peak crop out-of-season.

GENETIC COMPATIBILITY

The danger of planting a number of seedlings which are entirely cross—as well as self-incompatible—is rather remote but it should not be forgotten. Experiments at Serdang indicate that cross pollination is entirely adequate and not a factor which limits yield at any season of the year.

In Figure 4 to the seasonal yield variation of self-compatible and self-incompatible trees is shown. Both types have a very similar curve.

Table 11 shows that the contents of pods on three self-incompatible trees at Serdang were unaffected by hand pollination with a compatible pollen, but this number of tests is too few to prove conclusively that natural open pollination is adequate.

GROWTH OF THE IMMATURE TREE

The earliest stage at which one can measure the immature plant is when it is still a bean freshly extracted from the pod. An attempt was made to examine the size of a hybbrid bean at this stage compared with the average open pollinated bean size for the mother clone, and to

---

* A *skew* distribution of pod classes is quite usual in West Africa (11).

Table 11

The effect of hand pollination on the pod quality of self-incompatible trees

Self incompatible tree number	*Pollination	Pod value (gms)	Bean weight (gms)	% flat beans
269	open	113	4.0	5
	hand	120	3.8	6
594	open	167	4.4	7
	hand	140	4.5	7
474	open	149	4.2	6
	hand	145	4.2	5

(* not less than 10 pollinations of each type. The trees are growing at Serdang in experiment C.6).

correlate the difference* with the growth of the young hybrid seedling. The results are shown in Figure 5.

Since no relationship has been demonstrated between absolute bean weight and seedling vigour it is not surprising the change in bean weight has also failed to show any correlation with girth.

Studies of tree habit and the height at which jorquetting commences have been confused by the effects of *die-back* and pruning. It has therefore been assumed that the girth of the seedling stem one foot above ground is the best criterion to use for growth studies. The figures in Table 13 show that the girth of the young seedlings in Experiment C.5 and C.6 at Serdang gave no true indication of their future yield ($r=0.2$ and 0.3) but at Jerangau there is a significant positive correlation (Figure 6). It is too soon to establish what the yield of the trees at Jerangau will be when they mature but, since they are planted so close together (680) per acre), differences between individual trees are likely to become less with age (14) while differences between progenies could become greater.†

* It has been mentioned that no consistent effect on pod or been quality was caused by hand pollination itself.

† In Trinidad, Maliphant has shown (14) that the correlation between the girth of cacao trees at 3½ years and successive annual crops remains good for widely spaced trees but disappears after one season for trees which are closely spaced and shaded.

Age of bearing or precocity

The date on which a tree comes into bearing is entirely dependent upon its physiological age. That is to say, if trees can be given optium conditions at all stages of growth then they will come into bearing much sooner than others grown under adverse conditions. Since no progeny trials in Malaya have received optimum conditions at all stages of growth it is not possible to state categorically that some varieties are more precocious than others. However, under adverse conditions, some varieties do succeed in growing better than others and so reach the physiological age of fruiting earlier.

Rogers has suggested that, "It may be more desirable for a tree to build up its framework before diverting its energy to the production of pods. There has always been the contention that some of the *Upper Amazon* types may be too vigorous and their yields reach a peak at too early an age. The breeder is handicapped by lack of knowledge . . . . . ." (13).

Unfortunately, we cannot learn any more from the Malayan results since any decline in yield with age could be attributed to *die-back*. However, it is worth recording that the progenies with the greatest girth at one year are often amongst the first to come into bearing and they continue to give relatively high yields for at least the first three years of bearing. (Figs. 6 & 7).

Pod and bean quality

The recovery rate of dry cocoa from fresh Amelonado beans may vary between 32% and 42% but in fact is usually about 40%. This rate does not seem to be greatly affected either by the locality in which the beans are grown or by minor differences in fermentation technique. Seasonal differences in recovery rate are probably associated with the variation in fresh bean weight. (Fig. 8)

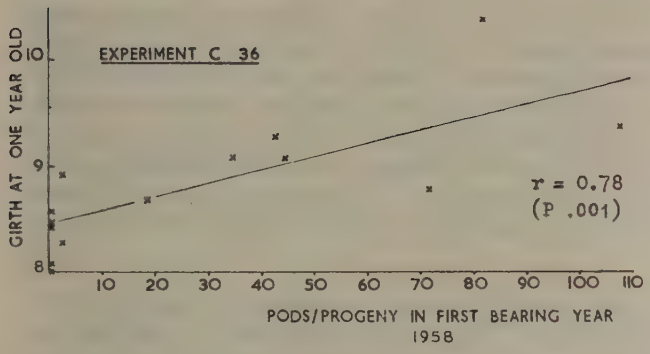
Summary

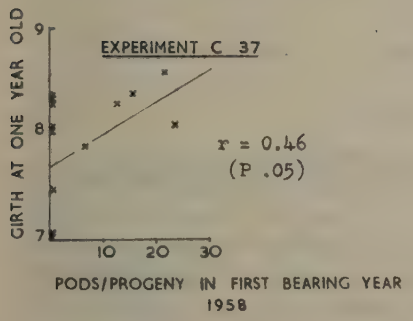
In Part I, the cacao selection and breeding programme is traced in rough chronoligical order from the circumstances in which *Amelonado* became the recommended variety of cacao in Malaya up to the present day proposals to plant clonal seed gardens for the production of *progeny tested* hybrid seed.

The yield components of hybrid progenies are examined according to their parentage and it is suggested that the best hybrids usually have one parent which is an *Upper Amazon* clone. Apart from this, no one *type* of hybrid cross has been proved to be superior to the others although "*Upper Amazon* crossed with *Malayan Criollo*" has the highest average yield. An attempt has been made to select a few *élite* progenies and

Figure 7

Girth at one year as an indication of prococity.





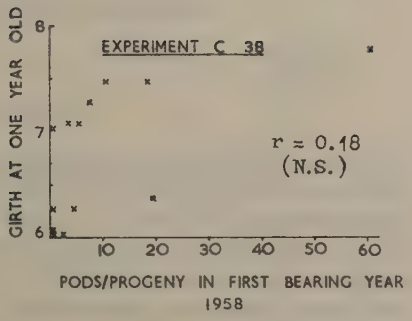
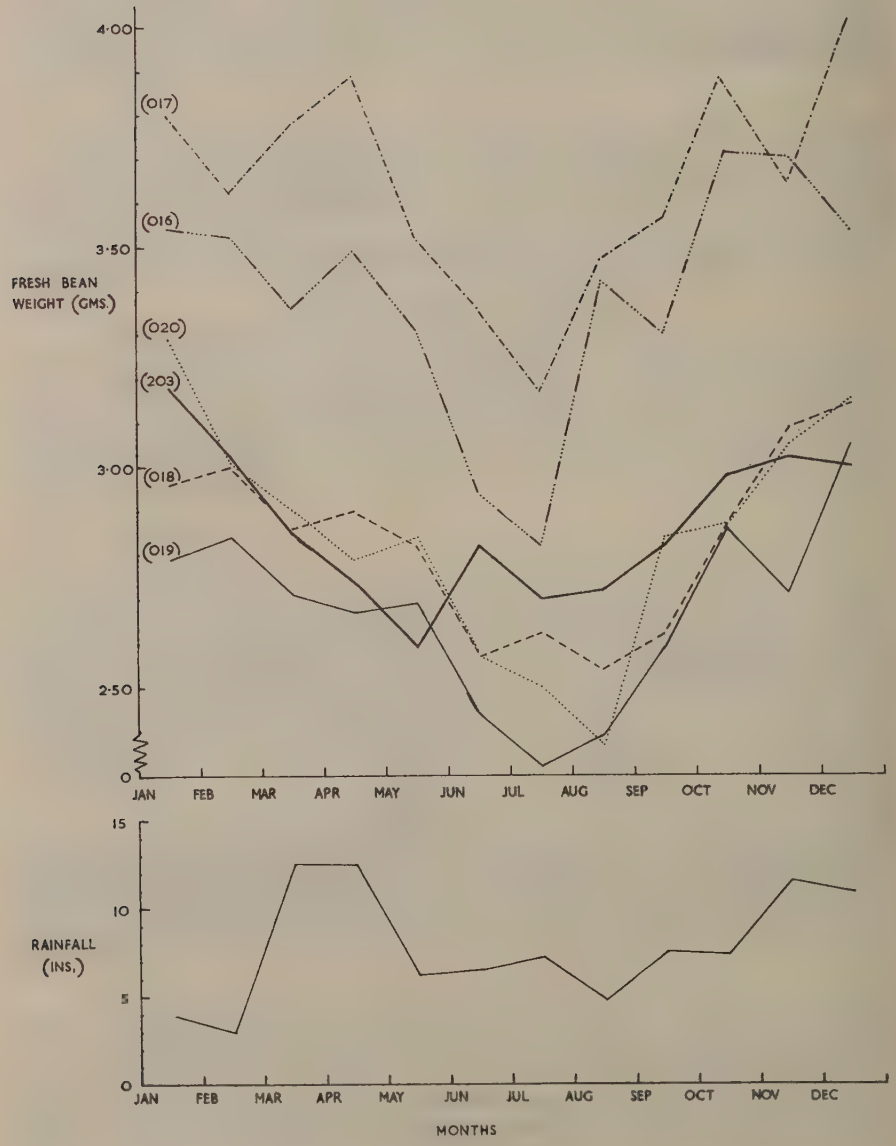


Figure 8

Seasonal variation in the weight of an average fresh bean
(progenies in experiment C. 6)



having studied their parentage to make recommendations regarding the composition of cacao clonal seed gardens. *Upper Amazon* clone number 423, propagated from a selected seedling at Serdang, has so far proved to be the most outstanding parent.

Yields from small plots can be misleading when converted into the equivalent number of pounds per acre and the author has tried to stress comparative rather than absolute figures. On this basis it is considered that, so long as *die-back* disease is uncontrolled, the best *Upper Amazon* hybrids will give at least double the yield obtained from *Amelonado* during the first three years of bearing. At present there is no sign that the hybrids become exhausted at an early age although their maximum yield will probably be limited when the trees are too closely spaced or over shaded. If *die-back* disease can be brought under control, yields of 1,000 lbs. per acre can be confidently predicted* in future.

In Part II, attention is drawn to a few of the other factors which influence the yield of cacao in Malaya. The correlation between early growth and subsequent yield is discussed and mention is made of the importance of uniformity and genetic compatibility. It is concluded that hybrid planting material is by no means a panacea or a substitute for good field management.

Summary Table 32: Clones used for breeding—their origin and principal characteristics.

Summary Table 33: Clones used for breeding—the number and location of progeny tests.

Summary Table 34: Progenies—their parentage and location.

Acknowledgements

Only a few names can be mentioned from the many members of the public and the Department of Agriculture, who have contributed towards the work described in this article. The initial plant breeding at Serdang carried out by E. A. Rosenquist, under the direction of the former Director of Agriculture, O. J. Voelker, formed the invaluable basis for it. The field trials were planted with assistance from the Agronomists, C. Whitehead and C. R. Raper and in this connection a particular tribute must be paid to Inche Jusoh bin Mohd. Zain for his pioneering work at F.E.S. Jerangau. Amongst the Botany Division Junior Staff who have dealt with these experiments, Inche Tahareim bin Meon must be thanked for his meticulous pollination work and Inche2 Y. L. Tong and A. Tan for many tedious hours at the calculating machines.

---

* Yields of more than 3,000 lbs./acre have already been obtained at W.A.C.R.I. (9).

The management of estates on which cacao is planted have always been most co-operative. In particular the author would like to thank Mr. D. H. Telfer and Mr. C. C. Brooker of the estate in Trengganu and Mr. R. L. Grut and his assistants at Kuala Bernam Estate for their kindness on many occasions and also for permission to publish the results given in this article.

The staff of Harrisons & Crosfield (Federation of Malaya) Limited, have also freely offered their encouraging assistance and this is acknowledged with gratitude.

References

(1) Allen, E. F. (1953) : "Investigations into the cultivation of cacao in Malaya" Malayan Agric. Journal, **36.** 147.

(2) Cheesman, E. E. (1948) : Report on the potentialities for cultivation of Cocoa in Malaya, Sarawak and N. Borneo. H.M. Stationery Office, London.

(3) Conaty, F. N. G. and Smith, M. (1958) : "Microfermentation of Cocoa for selection work" Malayan Agric. Journal, **41.** 39.

(4) Cope, F. W. and Bartley, B. G. (1954) : "Some aspects of the Plant Improvement Programme" Report on Cacao Research, I.C.T.A., Trinidad (p.27).

(5) Cope, F. W. (1956) : Proceedings of Cacao Breeding Conference (p.21).

(6) Eden, D, R. A. (1953) : Report of the Cocoa Conference, London (p.22).

(7) Fennah, R. G. and Murray, D. B. (1957) : "The cocoa tree in relation to its environment" Report of the Cocoa Conference, London.

(8) Glendinning, D. R. (1960) : "The relationship between growth and yield in cocoa varieties" Euphytica, **9.** 351.

(9) Glendinning, D. R. (1960) : "Plant breeding at the West African Cacao Research Institute" Proceedings of the VIII Inter-American Cacao Conference (p.374).

(10) Howatt, G. R. (1956) : "Manufacturers' requirements as breeding characters" Proceedings of the Cacao Breeding Conference, Ghana (p.26).

(11) Knight, R. and Rogers, H. H. (1955) : "Introductions to W. Africa of Theobroma cacao : I" The Empire Journal of Experimental Agriculture. **23.** 13.

(12) Knight, R and Rogers, H. H. (1955) : "Incompatibility in Theobroma cacao" Heredity. **9.** 69.

(13) Knight, R. and Rogers, H. H. (1955) : "Plant breeding at the West African Cacao Research Institute" Report of the Cocoa Conference, London.

(14) Maliphant, G. K. (1959) : "The cacao tree size-yield correlation" Report on Cacao Research. Trinidad. (1957-'58).

(15) McKelvie, A. D. (1956) : "WACRI Breeding Material" Proceedings of the Cacao Breeding Conference (p.10).

(16) Pound, F. J. (1938) : "Cacao and Witchbroom Diseases of South America" Port of Spain, Trinidad.

(17) Rosenquist, E. A. (1950) : "Cocoa selection and breeding in Malaya" Malayan Rgric. Joural, **33.** 181.

(18) Rosenquist, E. A. and Sockalingam, T. (1953) : "Amelonado cocoa in Malaya" Malayan Agric. Journal, **36.** 164.

(19) Russel, T. A. (1952) : "The vigour of some cocoa hybrids" Tropical Agriculture, **29.** 102.

(20) Thompson, A. (1950) : "The introduction of Amelonado cocoa from the Gold Coast to Malaya" Malayan Agric. Journal, **33.** 209.

(21) Wadsworth, R. V. (1955) : "The quality of raw cocoa as it affects the manufacture" Tropical Agriculture, **32.** 1.

Table 12

Malayan Trinitario versus West African Amelonado
Experiment C.5 (FESS 97)

Variety	Cross Numbers	Pod value (gms)	Bean weight (gms)	Yield of dry cocoa (lbs/acre)				
				1954	1955	1956	1957	Mean
A Amelonado	201	116	2.8	353	452	308	501	404
B Near-Criollo	114 & 115	121	4.0	201	412	265	511	347
C Near-Forastero	100, 116, 117, 118 & 120	68	3.0	145	280	172	377	244
S.E. (13)		2	0.1	44	42	41	45	38

Location: Federal Experiment Station, Serdang. Date planted: March 1950

Planting distance: 12′ x 12′ (square). Shade: Planted legumes.

Design: Randomised Block. 7 Replications of main treatments but unequal replication of individual crosses. Trees per plot: 30

(Note: in this, and all other Tables, *pod value* refers to the mean weight of fresh beans per pod and *bean weight* refers to the mean weight of one fresh bean. *Yield* is calculated as the product of pod value and pod number at an assumed constant recovery rate of 40%—unless stated otherwise).

Table 13

Height, Girth and Yield Records
from cacao progenies at F.ES. Serdang
Experiment C.5

Variety	Cross Numbers	Height (cms)		Girth (cms)			Yield of dry cocoa (lbs/acre)				
		1 year	2 years	1 year	2 years	3 years	4 years	5 years	6 years	7 years	Mean
nelonado	201	178	231	8.0	14.8	21.8	353	452	308	501	404
ear-Criollo	114 & 115	200	256	9.5	15.5	22.6	201	412	265	511	347
ear-Forestero	100, 116, 117, 118 & 200	152	231	7.5	14.3	20.2	145	280	172	377	244
S.E. (13)		±4.0	±4.0	±0.1	±0.3	±0.3	±44	±42	±41	±45	±38

Experiment C.6

Variety	Cross Numbers	Height (cms)		Girth (cms)			Yield of dry cocoa (lbs/acre)				
		1 year	2 years	1 year	2 years	3 years	4 years	5 years	6 years	7 years	Mean
Getas 8	081	169	209	9.2	12.6	21.0	317	636	843	659	614
atiroenggo 1	082	171	203	8.5	11.2	19.3	352	763	850	617	646
erbojo 4 (red)	083	165	203	7.8	10.2	19.2	384	647	733	667	608
erbojo 6 (green)	084	145	187	6.9	9.0	17.9	348	578	745	737	602
zannasdaal	085	169	219	7.6	10.7	19.2	485	776	856	634	688
acassar Amelonado	203	159	186	7.7	10.3	20.1	543	853	917	1022	834
S.E. (20)		±9.5	±13.0	±0.5	±0.6	—	±68	±105	±104	±98	±56

For experiment details refer to Tables 12 and 14.

Table 14

Indonesian Trinitario versus Macassar Amelonado

Experiment C.6 (FESS 115)

Variety	Cross Numbers	Pod value (gms	Bean weight (gms)	Yield of dry cocoa (lbs/acre)				
				1954	1955	1956	1957	Mean
Getas 8	016	104	3.3	317	636	843	659	614
Djatiroenggo 1	017	104	3.5	352	763	850	617	646
Poerbojo 4 (red)	018	93	2.7	384	647	733	667	608
Poerbojo 6 (green)	019	89	2.5	348	578	745	737	602
Suzanna'sdaal	020	99	2.7	485	776	856	634	688
Macassar Amelonado	203	109	2.6	543	853	917	1022	834
S.E. (20)		±3	±0.1	±68	±105	±104	±98	±56

Location: Federal Experiment Station, Serdang.

Date planted: Sept., 1950

Planting distance: 10′ x 10′ (square).

Shade: Planted legume and *Mallotus* spp.

Design: Latin Square.

Trees per plot: 20 (5 x 4).

Table 15

Cacao collection from West Africa (C.7)

Description of parental variety in Ghana	Cross Numbers	No. of trees planted	Estimated yield of dry cocoa (lbs/acre) when 10 pods=1 lb.					
			1956	1957	1958	1959	1960	Mean
T.9 Trinitario Costa Rica	034	316	61	294	249	486	338	286
U.11 Approx. Cundeamor	035	166	39	295	252	449	231	243
E.1 Local hybrid	036	142	13	104	98	301	159	137
T.F.1 Local hybrid almost Amelonado	039	38	7	46	68	93	139	71
T.F.2 Local hybrid	043	69	0	3	0	20	17	8
B.2 Trinitario	042	42	2	47	24	257	174	101
N.38 Amelonado	041	42	2	47	25	158	83	63
ICS 1 Trinitario	038	77	22	153	180	439	252	209
ICS 7 Trinitario	037	56	2	17	12	99	76	41
ICS 9 Trinitario	040	14	0	31	25	87	90	47

Location: Federal Experiment Station, Serdang.

Planting distance: 10′ x 10′ (square).

Design: Unreplicated blocks.

Date planted: May 1951.

Shade: Thinned *belukar* and some remaining *Hydnocarpus Woodii.*

Trees per block: *see* table above.

Table 16

Cacao collection from Keravat, New Guinea (C.22)

Parental variety	Cross Numbers	Number of seedlings	Estimated yield (lbs/acre) (12 pods=1 lb. 1956-1960	
			Field 47	Field 49
K. 4	029	37	22.2	(absent)
K.13	030	77	50.8	108.6
K.16	031	67	6.0	19.8
K.19	032	52	49.6	(absent)
K.28	033	76	42.2	44.0

Location: Federal Experiment Station, Serdang. Date planted: October, 1951.

Planting distance: 10′ x 10′ (square). Shade: Thinned belukar and some remaining *Hydnocarpus Woodii*.

Design: Unreplicated blocks. Trees per block: *see* table above.

Table 17

Upper Amazon seedling collection from W.A.C.R.I. (C.27)

W. A. C. R. I.			Serdang Cross No.	No. of trees planted	Pod value (gms)	Bean weight (gms)	Yield of dry cocoa (lbs/acre)				
Import No.	Tree No.	Parentage					1954	1955	1956	1957	Mean
T.12	62	Scavina 12	494	10	110	2.9	50	332	566	641	397
T.12	114	Scavina 12	495	3	117	3.0	53	383	691	653	445
T.56	59	Morona 12	496	6	100	2.8	67	86	156	108	104
T.60	962	Pa.7 x Na.32	497	2	110	3.1	22	218	351	237	207
T.63	966	Pa.35 x Na.32	498	7	77	3.1	31	187	457	354	257
T.86	955	Pa.35 x Na.37	499	11	96	2.6	275	391	741	490	474
Mean (weighted)				39	100	2.7	111	283	531	445	343

Location: Federal Experiment Station, Serdang.

Date planted: October, 1952.

Planting distance: 12′ x 12′ (square).

Shade: Planted legumes.

Design: Random mixture of seedlings.

Table 18

Jerangau Hybrid Progeny Trial No.1
Experiment C. 36

Variety or type of hybrid	Cross Numbers	Pod value (gms)	Bean weight (gms)	Number of pods per acre per annum				Girth of main stem 1' above ground (cms)		
				1958	1959	1960	Mean	1 year	2 years	3 years
Amelonado control	202	141	3.1	34	261	1122	476	8.9	13.7	17.8
Upper Amazon crossed with S.I.Trinitario	750	153	3.8	487	2175	5302	2651	9.3	14.6	20.6
	751	149	3.6	929	2005	6084	3002	10.4	16.5	22.2
	752	142	3.5	397	1099	4113	1869	9.1	15.3	22.2
Upper Amazon crossed with Criollo	850	144	4.0	1224	2357	7421	3671	9.4	15.3	21.3
Upper Amazon crossed with Amelonado	700	122	2.9	510	2776	9132	4135	9.1	14.9	21.4
S.I.Trinitario crossed with S.C.Trinitario	140	147	4.0	11	159	929	363	8.0	12.2	17.3
	141	115	3.3	34	306	827	385	8.3	12.2	16.1
S.I.Trinitario crossed with Amelonado	900	118	3.2	0	181	567	249	8.0	12.3	15.8
	901	143	4.1	816	1949	3999	2255	8.8	14.3	20.9
	902	158	4.3	159	725	3773	1552	8.7	14.7	19.9
S.C.Trinitario crossed with S.C.Trinitario	180	129	3.2	11	170	1246	476	8.6	12.9	16.4
	181	129	3.3	0	57	804	283	8.5	13.5	18.1
S.C.Trinitario crossed with Amelonado	950	128	3.4	0	227	858	351	8.5	12.8	16.4
S.E.*				±363 (24)	±476 (44)	±1354	±626	±0.6	±1.0	±1.3

Location: Federal Experiment Station, Jerangau. Date planted: November, 1955
Planting distance: 8' x 8' (square) Shade: Thinned jungle.
Design: Randomised Block with 5 replications. Trees per plot: 12 (4 x 3).

(*the number of degrees of freedom for error is normally 52 but varies according to the number of varieties included in the analysis. Varieties which produced no pods from 3 or more plots were excluded).

Table 19

Jerangau Hybrid Progeny Trial No.2
Experiment C.37

Variety or type of hybrid	Cross Numbers	Pod value (gms)	Bean weight (gms)	Number of pods per acre per annum				Girth of main stem 1′ above ground (cms)		
				1958	1959	1960	Mean	1 year	2 years	3 years
Amelonado control	202	x	x	0	0	11	3	7.0	9.3	12.1
Upper Amazon crossed with Upper Amazon	400	101	2.6	79	476	3320	1292	7.9	12.6	18.2
	401	102	2.6	181	861	4600	1881	8.4	12.8	17.7
Upper Amazon crossed with S.I.Trinitario	753	156	3.9	249	668	3036	1314	8.6	12.7	18.0
	754	124	3.0	272	940	3886	1700	8.1	13.6	19.5
Upper Amazon crossed with S.C.Trinitario	800	136	3.4	147	793	2629	1190	8.3	12.4	17.0
	801	98	2.4	0	11	113	45	7.0	9.9	13.7
Upper Amazon crossed with Criollo	851	109	3.3	0	23	510	181	8.4	10.6	14.7
Upper Amazon crossed with Amelonado	701	107	2.5	0	113	1076	397	8.4	11.8	16.3
	702	138	3.7	0	23	578	204	8.3	11.3	14.0
S.I.Trinitario crossed with S.C.Trinitario	142	128	3.4	0	45	147	68	7.5	10.0	12.9
	143	138	3.5	0	68	895	317	8.1	11.7	16.6
S.I.Trinitario crossed with Amelonado	903	152	3.6	0	215	1337	521	8.1	12.9	19.0
S.C.Trinitario crossed with S.C.Trinitario	182	119	3.0	0	0	68	23	7.0	10.7	14.1
S.E.				—	±289 (16)	±640 (32)	±208 (44)	±0.4	±0.6	±1.2

Date planted: May, 1956.

Other experiment details as for C.36 in Table 18.

Table 20

Jerangau Hybrid Progeny Trial No.3
Experiment C.38

Variety or type of hybrid	Cross Numbers	Pod value (gms)	Bean weight (gms)	Number of pods per acre per annum				Girth of main stem 1′ above ground (cms)		
				1958	1959	1960	Mean	1 year	2 years	3 years
Amelonado control	202	114	3.6	0	5	16	7	6.0	6.9	9.3
	403	115	3.0	215	1484	6130	2606	7.5	11.8	17.5
	404	119	3.1	125	986	5212	2107	7.5	11.9	18.4
	405	125	2.9	45	929	4351	1779	7.1	12.0	17.9
Upper Amazon	406	130	3.3	11	363	3036	1133	6.0	9.6	14.2
crossed with	407	118	2.9	68	1088	5268	2141	7.1	11.8	17.9
Upper Amazon	408	126	3.2	57	929	4657	1881	6.8	10.9	16.2
	409	135	3.2	91	487	1767	782	7.3	11.0	15.8
	410	138	3.4	57	499	3909	1484	6.3	10.3	15.4
	411	132	3.2	227	442	4351	1677	6.4	10.8	16.0
	412	133	3.4	34	215	1643	634	6.0	9.2	14.2
Upper Amazon crossed with Criollo	852	120	3.1	691	1382	5563	2549	7.8	12.7	19.8
S.I.Trinitario	145	161	4.0	0	79	770	283	7.0	10.0	14.8
crossed with S.C.Trinitario	146	113	3.4	0	0	204	68	6.3	8.8	12.7
S.E.				±179 (32)	±470 (36)	±997	±510	±0.4	±0.7	±1.4

Date planted: August, 1956.

Other experiment details as for C.36 in Table 18.

Table 21

Jerangau Hybrid Progeny Trial No.4
Experiment C.41

Variety or type of hybrid	Cross Number	Pod value (gms)	Bean weight (gms)	Number of pods per acre per annum				Girth of main stem 1' above ground (cms)		
				1958	1959	1960	Mean	1 year	2 years	3 years
Amelonado control	202	x	x	0	0	0	0	6.3	8.3	10.1
Upper Amazon crossed with S.I.Trinitario	413	125	2.8	0	193	1246	476	5.8	9.2	13.9
	414	119	3.5	34	1122	2447	1201	6.7	11.6	16.3
	415	86	2.4	23	1224	1677	974	5.5	9.5	12.5
Upper Amazon crossed with S.I.Trinitario	755	120	3.2	11	385	385	261	6.8	11.0	14.5
	756	130	3.5	0	181	544	238	7.2	11.4	16.1
	757	142	3.4	193	1292	3002	1496	7.3	12.0	17.1
	758	153	3.9	147	2085	3138	1790	8.3	14.1	19.0
Upper Amazon crossed with S.C.Trinitario	803	160	4.3	0	283	1348	544	6.7	10.7	15.0
Upper Amazon crossed with Amelonado	703	122	3.0	11	11	442	159	7.2	12.1	17.4
S.I.Trinitario crossed with S.C.Trinitario	148	160	3.8	0	34	419	147	7.1	11.2	15.2
	149	102	2.9	0	34	872	306	7.4	11.4	16.0
	150	220	6.1	0	0	45	11	6.3	9.8	12.8
S.C.Trinitario crossed with Amelonado	952	109	3.0	0	11	363	125	7.0	11.0	14.3
S.E.				—	—	±816 (32)	±484 (36)	±0.6	±1.3	±1.7

Date planted: November, 1956.

Other experiment details as for C.36 in Table 18.

Table 22

Jerangau Hybrid Progeny Trial No.5
Experiment C.45

Variety or type of hybrid	Cross Numbers	Pod value (gms)	Bean weight (gms)	Number of pods per acre per annum				Girth of main stem 1′ above ground (cms)		
				1958	1959	1960	Mean	1 year	2 years	3 years
Amelonado control	202	144	3.6	0	0	0	0	6.1	7.7	8.2
Upper Amazon crossed with S.I. Trinitario	416	117	2.8	0	136	2062	736	5.2	9.7	13.7
	417	98	2.5	0	91	1110	397	5.5	8.7	13.4
Upper Amazon crossed with S.I. Trinitario	759	133	4.1	0	136	1144	431	6.8	9.9	13.9
	760	111	2.9	0	0	929	306	6.0	8.5	12.2
	761	153	4.0	0	11	1031	351	5.5	11.9	16.8
	762	146	3.6	0	170	1824	668	6.3	10.6	15.4
Upper Amazon crossed with Criollo	853	99	3.0	34	408	2164	872	7.4	10.6	14.5
S.I.Trinitario crossed with S.C.Trinitario	152	120	3.2	0	0	227	79	6.6	8.0	10.9
	153	127	3.5	0	0	306	102	6.4	8.1	11.4
	154	114	2.8	0	181	1235	476	6.6	11.5	17.1
	155	114	3.9	0	0	34	11	6.9	8.1	10.4
	156	120		0	11	91	34	6.4	9.4	12.9
S.C.Trinitario crossed with Amelonado	953	92	2.4	0	0	272	91	5.9	7.9	10.5
S.E.				—	—	±725 (32)	±270 (32)	±0.5	±1.0	±1.4

Date planted: December, 1956.

Other experiment details as for C.36 in Table 18.

Table 23

Jerangau Hybrid Progeny Trial No.6
Experiment C.47

Variety or type of hybrid	Cross Numbers	Pod value (gms)	Bean weight (gms)	Number of pods per acre per annum				Girth of main stem 1' above ground (cms)		
				1958	1959	1960	Mean	1 year	2 years	3 years
Amelonado control	202	x	x	0	0	0	0	5.3	6.1	8.5
Upper Amazon crossed with Upper Amazon	418	56	23	0	11	578	193	5.9	10.2	15.0
	419	137	43	0	181	1507	567	6.5	10.5	15.1
	420	x	x	0	0	23	11	5.4	8.4	13.6
Upper Amazon crossed with S.I.Trinitario	763	185	45	0	11	204	68	6.2	9.5	14.3
	764	x	x	0	0	0	—	5.3	8.7	12.9
Upper Amazon crossed with Amelonado	704	x	x	0	0	272	91	5.6	8.1	12.1
S.I.Trinitario crossed with S.C.Trinitario	157	80	34	0	23	283	102	6.8	10.7	15.3
	158	x	x	0	0	0	—	5.9	8.3	12.1
	159	x	x	0	0	11	3	4.9	8.2	11.8
S.I.Trinitario crossed with Amelonado	904	x	x	0	0	91	34	6.0	8.3	12.1
S.C.Trinitario crossed with S.C.Trinitario	183	x	x	0	0	181	57	5.5	8.7	13.0
S.C.Trinitario crossed with Amelonado	954	x	x	0	0	215	68	7.3	11.2	15.9
	955	x	x	0	0	11	3	5.6	8.8	12.7
S.E.				—	—	±398 (8)	±148 (8)	±0.3	±0.7	±0.9

Date planted: March and June, 1957.

Other experiment details as for C.36 in Table 18.

Table 24

Upper Amazon backcross progenies

Experiment C.48

Parent clone numbers (Female x Male)	Cross Number	Girth at 2 years (cms)	No. of pods/acre (1960)			Vigour (eye-score) Oct. 1958
			spacing 8′x8′	spacing 12′x12′	mean (1960)	
404 x 451 (IMC 76)	480	8.3	473	64	269	4.5
404 x 450 (IMC 60)	481	8.3	453	157	305	4.3
423 x 450 (IMC 60)	482	7.3	288	0	144	4.0
423 x 452 (Na.33)	483	11.3	1813	1107	1460	7.0
418 x 451 (IMC 76)	484	5.5	385	10	198	2.0
418 x 452 (Na.33)	485	6.8	302	109	206	5.0
Amelonado (3 rows) between trial Blocks	202	(7.0)	—	—	(0)	0.5
S.E. (15)		±1.2	—	—	±223	—

Location: Federal Experiment Station, Jerangau.

Date Planted: July, 1957.

Planting distance: 8′ x 8′ square or 12′ x 12′ square according to treatment.

Shade: Thinned jungle.

Design: Randomised block.
Spacing treatments in 2 replications.
Varieties as sub-treatments in 4 replications.

Trees per plot: 12 (4x3).

Note: Girth measurements taken 1′ above ground.
Eye scores given as the mean from four observers scoring 0– dead and 5– most vigorous.

Table 25

Inbred lines (C.43)

Parentage (selfed clone)	"Cross" Nnmbers	Girth at 2 years (cms)	No. of pods per acre/annum (1960)
757 (ICS 95)	500	9.7	48
750 (1CS 6)	501	9.1	612
393	502	10.3	120
394	503	9.0	24
355	504	7.7	72
042	505	7.9	0
044	506	6.4	24
124	507	16.1	0
601	508	9.2	0
602	509	8.0	0

Location: Federal Experiment Station, Jerangau. Date planted: 1956/57.
Planting distance: 8′ x 8′ (square). Shade: Thinned jungle.
Design: Unreplicated twin rows. Trees per plot: 58 (29x2).

Table 26

Near-Criollo lines (C.44)

Parent clone numbers (Female x Male)	Cross Number	Girth at 2 years (cms)	No. of pods per acre/annum (1960)
754 (ICS 45) selfed	525	8.8	0
051 selfed	526	7.9	84
083 selfed	527	7.6	0
121 selfed	528	9.8	0
755 (ICS 60) x 754 (ICS 45)	529	11.1	12
073 x 121	530	11.9	288
050 x 121	531	8.8	60
088 x 121	532	11.0	360
083 x 070	533	6.8	0
072 x 121	534	9.9	12

Location: Federal Experiment Station, Jerangau. Date planted: 1956/57.
Planting distance: 8′ x 8′ (square). Shade: Thinned jungle.
Design: Unreplicated twin rows. Trees per plot: 58 (29x2).

Table 27

Upper Amazon seedlings on a Trengganu Estate (C.58)

Clone numbers	Serdang parent tree no.	No. of seedlings	No. of pods/ac/ann.		Clone numbers	Serdang parent tree no.	No. of seedlings	No. of pods/ac/ann.	
			1959	1960				1959	1960
412	10	20	2,784	8,722	425	21	163	3,657	7,913
410	12	126	3,132	7,760	419	22	39	4,002	6,637
404	13	77	3,915	7,152	426	23	292	4,220	8,630
422	14	171	3,698	9,066	420	30	84	3,176	8,063
406	17	196	2,958	8,549	427	31	140	2,480	6,230
423	18	144	3,915	8,419	428	32	73	3,654	7,866
418	19	42	2,873	6,007	429	36	92	2,936	7,300
424	20	176	3,872	8,567	416	37	40	4,437	10,374

Note: Bulk fermentation of beans from this block shows that the conversion rate is about 12.6 pods per pound of dry cocoa.

Location: An Estate in Trengganu.

Date planted: 1955/'56.

Planting distance: 10′ x 10′ (square).

Shade: Thinned jungle.

Design: Observation. Progenies planted in rows of ussually 20 plants. The rows arranged approximately at random.

Table 28

Upper Amazon seedlings on a Trengganu Estate (C.59) 1956/57 Area

Parent clone numbers (Female x Male)	No. of seedlings	Number of pods/acre/annum			
		Actual		Corrected	
		1959	1960	1959	1960
423 x 420	35	547	6388	547	6388
410 x 418	35	447	6388	447	6388
416 x 428	35	261	7221	124	6068
428 x 423	35	621	7196	294	6047
428 x 400	35	410	6948	194	5839
412 x 423	35	534	6202	371	5796
408 x 412	105	514	5920	392	5719
405 x 403	70	584	5692	378	5390
426 x 410	35	286	5680	199	5308
428 x 421	35	845	5891	400	4950
420 x 410	35	224	5680	106	4773
420 x 419	35	497	5394	236	4533
404 x 415	105	543	4623	381	4460
412 x 420	35	298	4636	174	4458
404 x 424	35	348	5245	165	4408
403 x 411	140	472	4605	290	4274
411 x 403	35	224	4300	156	4019
400 x 428	35	87	4002	51	3848
420 x 417	35	385	3940	225	3788
410 x 400	70	255	3816	221	3701
400 x 430	35	12	2560	12	2560
412 x 430	35	211	2548	211	2548
427 x 420	70	316	4288	172	2249
Approx. S.E. (4)		±177	±423		

Note: (i) The original seed for these progenies was produced as a by-product of cross compatibility pollination tests. Since the progenies were not intended for planting in the field, and are not represented elsewhere (except for Cross No. 407:—404 x 424), they were not given Cross Numbers.

(ii) The 'corrected' pod number allows for the fertility gradient from Block 4 down to Block 1.

Location: An Estate in Trengganu. Date planted: 1956/57.

Planting distance: 10′ x 10′ (square). Shade: Thinned jungle.

Design: Observation. Progenies planted in rows. The rows arranged to form four Randomised Blocks with unequal replication of progenies. Trees per row: 35.

Table 29

Upper Amazon and other hybrid seedlings on Kuala Bernam Estate 1957 Area. (C.62)

Type of hybrid	Cross Number	No. of seedlings	Girth at 45 months (cms)	Yield of dry cocoa in 1960 (lbs/acre)
Upper Amazon (F2) crossed with Upper Amazon (F2)	403	77	24.0	Individual progeny yields are not available. Mean yield=560 lbs/acre.
	421	73	24.9	
	422	46	25.0	
	423	61	23.3	
Upper Amazon "Back-cross"	420	74	24.5	
	480	65	24.5	
	485	69	22.5	
Amelonado crossed with Upper Amazon (Po)	706	76	23.5	
	707	70	26.0	
	708	59	24.7	
Amelonado crossed with Upper Amazon (F2)	700	115	26.3	
	702	69	25.0	
	705	60	20.6	
Estate Amelonado of a similar age		100 (sample)	23.4	290

Location: Kuala Bernam Estate, Perak.

Date planted: October, 1957.

Planting distance: 14½′ x 10′ (rectangular) equiv. to 240 trees/acre.

Shade: Mature tall coconuts planted 20′ apart (triangular).

Design: Observation. Progenies in rows arranged approximately at random.

Trees per row: Up to 38.

Table 30

Upper Amazon seedlings on Kuala Bernam Estate
1958 Area. (C.63)

Parent clone Nos. (Female) x (Male)	Cross Number	Number of seedlings	Girth at 30 months (cms)	Yield of dry cocoa
452 (Na.33) x 457 (Pa.35)	451	86	19.9	Approximately 29 lbs/acre during the first 6 months of 1961.
452 (Na.33) x 456 (Pa.7	452	24	17.0	
450 (IMC 60) x 457 (Pa.35)	453	49	17.9	
450 (ICM 60) x 456 (Pa.7)	455	103	18.6	
451 (IMC 76) x 457 (Pa.35)	457	67	16.3	
404 x 403	424	51	15.1	

Location: Kuala Bernam Estate, Perak.

Date planted: November, 1958.

Planting distance: 14½′ x 10′ (rectangular) equiv. to 240/acre.

Shade: Mature tall coconuts planted at 28′ (triangular).

Design: Observation. Progenies in unreplicated blocks.

Trees per row: Up to 16.

Table 31

Yield of cacao on two Malayan Estates
(lbs/acre dry cocoa)
A Trengganu Estate.

Variety	Date of planting	Age from planting				
		3rd year	4th year	5th year	6th year	7th year
Amelonado	1953/54 (55 acres)	0	0	20	184	408
	1954/55 (79 acres)	0	4	75	205	—
	1955/56 (288 acres)	0	5	40	—	—
	1956/57 (43 acres)	5	—	—	—	—
Upper Amazon	1955/56 (5 acres)	13	224	591	—	—
	1956/57 (21 acres)	26	272	—	—	—
	1957/58 (18 acres)	52	—	—	—	—

Kuala Bernam Estate, Perak.

Variety	Date of planting	Age from planting				
		3rd year	4th year	5th year	6th year	7th year
Amelonado	1953 (1 acre)	—	—	—	215	474
	1954 (1 acre)	—	—	179	358	—
	1955 (11 acres)	—	311	476	—	—
	1956 (45 acres)	178	367	—	—	—
	1957 (32 acres)	292	—	—	—	—
Upper Amazon	1957 (4 acres)	563	—	—	—	—

In Trengganu the cacao is planted under thinned jungle on an inland granitic soil but at Kuala Bernam the soil is a more fertile alluvium and the cacao is planted under the shade of tall coconuts.

Table 32

Selected cacao clones used for breeding.

Clone No.	Genetic Origin		Location of original tree or clone in Malaya Serdang field/ tree No.	Pod value (gms)	Bean weight (gms)	Pod number per annum	Compatibility
	Type	Family Cross No.					
001	Malayan Trinitario	—	G.N./S. 68	124	2.2	—	S.C.
011	„ „	—	G.N./S. 27	91	3.2	—	S.I.
021	„ „	—	G.N./S. 15	130	4.2	—	S.C.
023	„ „	—	G.N./S. 21	88	3.0	—	S.C.
024	„ „	—	G.N./S. 47	82	3.4	—	S.I.
031	„ „	—	G.N./S. 43	154	5.5	—	S.C.
042	Indonesian Trinitario	016	47A/195	130	4.2	43	S.C.
044	„ „	016	47A/306	148	3.9	17	S.C.
049	„ „	016	47A/594	167	4.4	27	S.I.
050	„ „	016	47A/596	142	4.2	26	S.C.
051	„ „	016	47A/864	150	4.0	13	S.C.
070	„ „	017	47A/1154	140	4.2	21	S.C.
071	„ „	017	47A/173	172	4.7	12	S.I.
072	„ „	017	47A/198	134	4.6	30	S.C.
073	„ „	017	47A/200	104	3.5	35	S.C,
076	„ „	017	47A/474	149	4.2	35	S.I.
083	„ „	017	47A/131	123	3.6	15	S.C.
088	„ „	017	47A/1203	151	4.8	27	S.C.
103	„ „	018	47A/1148	112	2.7	78	S.I.
121	„ „	019	47A/230	107	3.1	50	S.C.
124	„ „	019	47A/466	102	2.5	70	S.C.
151	„ „	020	47A/269	113	4.0	53	S.I.
301	Malayan Trinitario	115	46A/269	156	4.9	14	S.I.
302	„ „	115	46A/352	166	5.6	20	S.I.
303	„ „	115	46A/385	175	4.6	23	S.I.
325	„ „	114	46A/224	178	4.9	12	S.I.
328	„ „	114	46A/582	157	5.8	15	S.I.
355	„ „	117	46A/521	81	3.0	49	S.C.
380	Malayan Criollo	301	45B/1124	106	3.4	11	S.C.
381	„ „	308	45B/407	67	3.1	1	S.C.
382	„ „ (?)	313	45B/29	90	3.2	1	S.C.
392	Ceylon Trinitario	051	Kinrara/714	109	3.4	—	S.C.
393	„ „	051	Kinrara/793	111	3.2	—	S.C.
394	„ „	051	Kinrara/1025	124	2.9	—	S.C.
395	„ „	051	Kinrara/1114	144	3.2	—	S.C.
403	Upper Amazon (F2)	494	50/9	136	3.2	28	S.I.
404	„ „	494	50/13	133	3.3	22	S.I.
410	„ „	495	50/12	121	3.0	34	S.I.
412	„ „	496	50/10	116	3.1	8	S.I.
413	„ „	496	50/28	84	2.1	8	S.I.
414	„ „	496	50/33	97	2.6	6	S.I.
415	„ „	497	50/8	141	2.9	6	S.I.
416	„ „	497	50/37	80	2.3	9	S.I.

Table 32—(*contd.*)

Selected cacao clones used for breeding.

Clone No.	Genetic Origin		Location of original tree or clone in Malaya Serdang field/ tree No.	Pod value (gms)	Bean weight (gms)	Pod number per annum	Compatibility
	Type	Family Cross No.					
418	Upper Amazon (F2)	498	50/19	137	3.3	16	S.I.
419	„ „	498	50/22	114	2.9	10	S.I.
420	„ „	498	50/30	112	2.9	15	S.I.
423	„ „	499	50/18	106	2.9	26	S.I.
424	„ „	499	50/20	104	2.6	34	S.I.
427	„ „	499	50/31	122	2.8	23	S.I.
428	„ „	499	50/32	127	2.9	17	S.I.
450	Upper Amazon (Po)	—	F.N./I.M.C. 60	181	4.7	—	S.I.
451	„ „	—	F.N./I.M.C. 76	192	4.7	—	S.I.
452	„ „	—	F.N./Na.33	—	—	—	S.I.
456	„ „	—	F.N./Pa.7	—	—	—	S.I.
457	„ „	—	F.N./Pa.35	—	—	—	S.I.
600	W. African Amelonado	201	46A/several	116	2.8	13	S.C.
601	„ „	201	46A/704	116	2.8	49	S.C.
602	„ „	201	46A/708	123	3.1	21	S.C.
700	Trinidadian Trinitario	022	47A/925	132	4.0	45	S.I.
701	„ „	022	47A/990	163	4.1	26	S.C.
750	„ „	—	F.N./1.C.S. 6	209	4.6	—	S.I.
752	„ „	—	F.N./I.C.S. 39	154	4.3	—	S.I.
754	„ „	—	F.N./I.C.S. 45	—	—	—	
755	„ „	—	F.N./I.C.S. 60	197	4.9	—	S.I.
756	„ „	—	F.N./I.C.S. 89	157	5.1	—	S.I.
757	„ „	—	F.N./I.C.S. 95	82	2.1	—	S.C.

NOTE: The figures for pod quality and number were obtained from individual trees (except where no pod number is given) and must therefore be treated with caution.

Pod numbers are calculated from the crop produced by the trees from 4 to 8 years of age.

Table 33

Summary of progeny tests of the Serdang selected clones.

Clone number \ Trial number	Cross Number											Total No. of different crosses per clone	
	C.5	C.36	C.37	C.38	C.41	C.43	C.44	C.45	C.47	C.48	C.62	C.63	Male	Female
001	M 114												2	0
	M 118													
011	F 116												0	3
	F 117													
	F 118													
021	F 114				F 148				F 904				0	6
	F 115				F 755									
					F 756									
023	M 100												2	0
	M 116													
024	F 100												0	2
	F 120													
031	M 115												3	0
	M 117													
	M 120													
042		M 950				FM 505		F 155					2(+1)	1(+1)
								M 152						
044		F 141	F 142	F 145		FM 506							3(+1)	3(+1)
		M 181	M 143											
			M 800											
049		F 140	F 903					M 153	M 158				2	3
		F 752												
050							F 531						0	1
051							FM 526						(+1)	(+1)
070							M 533						1	0
071		M 750	M 142						M 159				4	0
			M 753											
072							F 534						0	1
073							F 530						0	1
076					M 149								1	0
							F 533						(+1)	1(+1)

457											M 451			
											M 453			
											M 455	4	0	
											M 457			
600	FM*202	FM*202	FM*202	FM*202			FM*202	FM*202		F† 700		9(+1)	8(+1	
	F 900	F* 702		M 703				M 904		F* 702				
	F 950	M 701		M 952				M 955		F 705				
	M† 700	M 903								F 706				
	M 901									F 707				
	M 902									F 708				
601					FM 508							(+1)	(+1)	
602					FM 509							(+1)	(+1)	
700				F 757			M 953	M 704				3	1	
								M 954						
701				M 803			F 953					1	1	
750				F 150	FM 501							(+1)	(+1)	
752								F 763				0	1	
754						FM 525						1(+1)	(+1)	
						M 529								
755						F 529	F 156					0	2	
756							F 761					1	1	
							M 155							
757					FM 500			F 157				(+1)	3(+1)	
								F 183						
								F 954						

F=Female parent. M=Male parent.

NOTES:

* indicates that the progeny is represented in another trial.

† indicates that the progeny is represented as a reciprocal cross in another trial.

EXAMPLE: Clone number 393 is progeny tested as the male parent of cross number 182 (in trial C.37), as the female parent of cross number 955 (in trial C.47) and as the *selfed* progeny number 502 (in trial number C.43).

Progenies listed in Tables 27 & 28. are not included above.

Table 34

Origin and location of progenies under test.

Cross number	Female parent	Male parent	Experiment	
			Number	Location
016	Trinitario Gt.8	(clonal seed)	C.6	F.E.S. Serdang
017	Dr.1	Trinitario Dr.2	C.6	„
018	Pr.4	(clonal seed)	C.6	„
019	Pr.6	„ „	C.6	„
020	Suz.	„ „	C.6	„
022	„ ICS.1	open pollinated	Obs.	„
029	„ K.4	„ „	C.22	„
030	„ K.13	„ „	C.22	„
031	„ K.16	„ „	C.22	„
032	„ K.19	„ „	C.22	„
033	„ K.28	„ „	C.22	„
034	„ T.9	„ „	C.7	„
035	„ U.11	„ „	C.7	„
036	„ E.1	„ „	C.7	„
037	„ ICS.7	„ „	C.7	„
038	„ ICS.1	„ „	C.7	„
039	„ TF.1	„ „	C.7	„
040	„ ICS.9	„ „	C.7	„
041	„ N.38	„ „	C.7	„
042	„ B.2	„ „	C.7	„
043	„ TF.2	„ „	C.7	„
051	„ (Ceylon)	„ „	—	Kinrara Estate
100	„ S.47	Trinitario S.21	C.5	F.E.S. Serdang
114	„ 021 (S.15)	„ S.68	C.5	„
115	„ 021 (S.15)	„ S.43	C.5	„
116	„ S.27	„ S.21	C.5	„
117	„ S.27	„ S.43	C.5	„
118	„ S.27	„ S.68	C.5	„
120	„ S.47	„ S.43	C.5	„
140	„ 049	„ 121	C.36	F.E.S. Jerangau
141	„ 044	„ 151	C.36	„
142	„ 044	„ 071	C.37	„
143	„ 325	„ 044	C.37	„
145	„ 044	„ 303	C.38	„
146	„ 325	„ 394	C.38	„
148	„ 021	„ 124	C.41	„
149	„ 124	„ 076	C.41	„
150	„ 750	„ 328	C.41	„
152	„ 302	„ 042	C.45	„
153	„ 392	„ 049	C.45	„
154	„ 303	„ 124	C.45	„
155	„ 042	„ 756	C.45	„
156	„ 755	„ 395	C.45	„
157	„ 757	„ 103	C.47	„

Table 34—(*contd.*)

Origin and location of progenies under test.

Cross number	Female parent	Male parent	Experiment	
			Number	Location
158	Trinitario 394	Trinitario 049	C.47	F.E.S. Jerangau
159	„ 355	„ 071	C.47	„
180	„ 124	„ 121	C.36	„
181	„ 124	„ 044	C.36	„
182	„ 124	„ 393	C.37	„
183	„ 757	„ 355	C.47	„
201	Amelonado Aburi	open pollinated	C.5	F.E.S. Serdang
202	„ 600	Serdang seed garden	Control in hybrid trials	
203	„ Macassar	open pollinated	C.6	F.E.S. Serdang
400	Upper Amazon 424	Upper Amazon 412	C.37	F.E.S. Jerangau
401	„ 423	„ 427	C.37	„
403	„ 423	„ 404	C.38	„
			C.62	Kuala Bernam Estate
404	„ 404	„ 412	C.38	F.E.S. Jerangau
405	„ 410	„ 424	C.38	„
406	„ 424	„ 418	C.38	„
407	„ 404	„ 424	C.38	„
408	„ 418	„ 423	C.38	„
409	„ 412	„ 415	C.38	„
410	„ 428	„ 418	C.38	„
411	„ 418	„ 420	C.38	„
412	„ 420	„ 404	C.38	„
413	„ 415	„ 427	C.41	„
414	„ 418	„ 419	C.41	„
415	„ 413	„ 404	C.41	„
416	„ 416	„ 418	C.45	„
417	„ 414	„ 403	C.45	„
418	„ 416	„ 403	C.47	„
419	„ 412	„ 418	C.47	„
420	„ 423	„ 450	C.47	„
			C.62	Kuala Bernam Estate
421	„ 423	„ 410	C.62	„
422	„ 424	„ 415	C.62	„
423	„ 404	„ 418	C.62	„
424	„ 404	„ 403	C.63	„
451	„ 452	„ 457	C.63	„
452	„ 452	„ 456	C.63	„
453	„ 450	„ 457	C.63	„
455	„ 450	„ 456	C.63	„
457	„ 451	„ 457	C.63	„
480	„ 404	„ 451	C.48	F.E.S. Serdang
			C.62	Kuala Bernam Estate
481	„ 404	„ 450	C.48	F.E.S. Jerangau
482	„ 423	„ 450	C.48	„
483	„ 423	„ 452	C.48	„

Table 34—(*contd.*)

Origin and location of progenies under test.

Cross number	Female parent	Male parent	Experiment	
			Number	Location
484	Upper Amazon 418	Upper Amazon 451	C.48	F.E.S. Jerangau
485	„ 418	„ 452	C.48	„
			C.62	Kuala Bernam Estate
494	„ T.12-62	open pollinated	C.27	F.E.S. Serdang
496	„ T.56-59	„ „	C.27	„
497	„ T.60-962	„ „	C.27	„
498	„ T.63-966	„ „	C.27	„
499	„ T.86-955	„ „	C.27	„
500	Trinitario 757	Selfed	C.43	F.E.S. Jerangau
501	„ 750	„	C.43	„
502	„ 393	„	C.43	„
503	„ 394	„	C.43	„
504	„ 355	„	C.43	„
505	„ 042	„	C.43	„
506	„ 044	„	C.43	„
507	„ 124	„	C.43	„
508	Amelonado 601	„	C.43	„
509	„ 602	„	C.43	„
525	Trinitario 754	„	C.44	„
526	„ 051	„	C.44	„
527	„ 083	„	C.44	„
528	„ 121	„	C.44	„
529	„ 755	Trinitario 754	C.44	„
530	„ 073	„ 121	C.44	„
531	„ 050	„ 121	C.44	„
532	„ 088	„ 121	C.44	„
533	„ 083	„ 070	C.44	„
534	„ 072	„ 121	C.44	„
700	Upper Amazon 423	Amelonado 600	C.36	„
			C.62	K. B. Estate (reciprocal)
701	„ 424	„ 600	C.37	F.E.S. Jerangau
702	Amelonado 600	Upper Amazon 404	C.37	„
			C.62	Kuala Bernam Estate
703	Upper Amazon 412	Amelonado 600	C.41	F.E.S. Jerangau
704	„ 418	„ 600	C.47	„
705	Amelonado 600	Upper Amazon 418	C.62	Kuala Bernam Estate
706	„ 600	„ 452	C.62	„
707	„ 600	„ 450	C.62	„
708	„ 600	„ 451	C.62	„
750	Upper Amazon 423	Trinitario 071	C.36	F.E.S. Jerangau
751	Trinitario 303	Upper Amazon 427	C.36	„
752	„ 049	„ 427	C.36	„
753	Upper Amazon 404	Trinitario 071	C.37	„

Table 34—(*contd.*)

Origin and location of progenies under test.

Cross number	Female parent	Male parent	Experiment	
			Number	Location
754	Upper Amazon 404	Trinitario 303	C.37	F.8.S. Jerangau
755	Trinitario 021	Upper Amazon 414	C.41	„
756	„ 021	„ 412	C.41	„
757	„ 700	„ 428	C.41	„
758	„ 302	„ 423	C.41	„
759	„ 325	„ 412	C.45	„
760	„ 103	„ 412	C.45	„
761	„ 756	„ 403	C.45	„
762	„ 151	„ 424	C.45	„
763	„ 752	„ 418	C.47	„
764	„ 103	„ 413	C.47	„
800	Upper Amazon 404	Trinitario 044	C.37	„
801	Trinitario 124	Upper Amazon 424	C.37	„
803	Upper Amazon 404	Trinitario 701	C.41	„
850	Criollo 380	Upper Amazon 427	C.36	„
851	Upper Amazon 412	Criollo 381	C.37	„
852	„ 423	„ 382	C.38	„
853	„ 404	„ 382	C.45	„
900	Amelonado 600	Trinitario 151	C.36	„
901	Trinitario 301	Amelonado 600	C.36	„
902	„ 328	„ 600	C.36	„
903	„ 049	„ 600	C.37	„
904	„ 021	„ 600	C.47	„
950	Amelonado 600	Trinitario 042	C.36	„
952	Trinitario 124	Amelonado 600	C.41	„
953	„ 701	„ 600	C.45	„
954	„ 757	„ 600	C.47	„
955	„ 393	„ 600	C.47	„

Note: Progenies listed in Tables 27 & 28, are not included in this table.

SUCCESSFUL INOCULATION OF OIL PALMS WITH A PURE CULTURE OF GANODERMA LUCIDUM

BY

S. J. NAVARATNAM,

Plant Pathologist.

Summary

To find out the method of disease spread in the field, roots and stems of oil palms were inoculated with a pure culture of *Ganoderma lucidum*. The disease was transmitted in both types of inoculations, but success was poor and is thought to be due to faulty technique.

Introduction

The earliest recorded association of a palm disease with *Ganoderma lucidum* in Malaya was in 1931 by Thompson(1). On a few oil palm estates he found some palms affected by a stem rot at about four feet from the ground and a few cases where the base of the palm was involved. The fungi associated with the disease were *Fomes* sp. resembling *F. pachyphloeus, Fomes applanatus, Ganoderma lucidum, Thielaviopsis paradoxa* and *Fomes lamaoensis*. From inoculation experiments and field observations he concluded that *F. pachyphloeus* was the probable cause of the disease. Two forms of sporophores were refered to in his paper. The atypical hardly laccate form which had a reddish-brown upper surface and the typical form with a dark-brown or black upper surface which was sometimes highly lacquered.

A few years before this paper was published, Sharples(2) had attributed a root disease of oil palms on 3 estates to a *Ganoderma* sp., but no sporophores were found and none developed subsequently for determination of the specific name. Tempany(3) in 1934 reported the discovery of *G. lucidum* sporophores on stems of areca palms which had died as a result of a root or stem disease. In 1935 (4) a root disease of 50 coconut palms was thought to have been caused by *G. lucidum*. In the same year the fungus was for the first time (5) considered a pathogen of oil palms producing a form of stem rot mainly of leaning palms. Later Thompson(6) reported finding palms growing on dried-out peat where *G. lucidum* infection appeared to have originated in the roots.

In post-war years, the disease was reported in 1951(7) and described as a basal stem rot. In 1956(8) it was considered a pathogen of some importance on one estate on palms over 20 years old and in the following year (9) observed for the first time on palms of 8 years old and subsequently appeared on younger palms.

From a survey carried out recently it was found that only palms growing on coastal soils were seriously affected and palms on upland soils were relatively free from this disease. Serious losses of palms were

encountered mainly on plantings over 30 years old, but in some cases especially where coconuts had been under-planted with oil palms and the former subsequently poisoned and felled, serious losses of young palms were experienced.

Overseas the fungus was first reported by Butler under its original name of *Fomes lucidus* as the causal agent for the betel nut plague in Sylhet, India (10). Petch in Ceylon found the fungus attacked coconuts and tea (11, 12). The disease on coconuts in Mysore referred to as 'anabe roga' is caused by *G. lucidum* (13). In inoculation experiments Narasimhan transmitted the disease to coconut palms (14). Venkatarayan used artificially infected portions of *Cassia siamea* to infect roots of areca and coconut palms (15). In Sumatra Dell (16) considered that high sodium and magnesium contents of low-lying soils reduced the vitality of the palms and enhanced their susceptibility to stem rot. Other factors which he considered weakened the palms and favoured the disease were poor soil structure found in coastal clayey soils, impermeable ground of marine origin and a high level of subsoil water preventing deep penetration of the roots, repeated floods especially in ill-drained areas and neglect of cultural measures such as weeding, manuring, thinning out and provision of drainage. Wijbrans considered that *G. lucidum* was a facultative parasite in Sumatra assuming an aggressive form only on palms weakened by injuries and adverse environmental factors (17). In Nigeria the disease is of widespread occurrence throughout the native oil palm holdings, but is normally restricted to palms more than 20 years old (18).

Symptoms

The first sign of the disease is the yellowing and drying up of the lowest fronds in the crown with the result that they hang down and form a cloak around the upper part of the trunk. Yellowing and drying up of fronds progresses slowly, affecting the lower fronds first and upper ones later. The leaflets in the terminal part of a frond are usually affected first, becoming pale green and then yellow and finally brown typical of desiccated fronds.

Sporophore production may occur first, but usually only after frond sysptoms such as yellowing and desiccation are obvious do sporophores begin to appear at the base of the stem or on exposed roots at soil level. Initially the young sporophores are small, hemispherical, closely adpressed to the trunk. As they mature the familiar bracket-shaped sporophores are formed. The upper surface of the fruit body is usually rather uneven, highly lacquered and slightly zoned. There is usually a clear white band between the outer edge of the sporophore and the boundary of the brown laccate area. The underside is covered with minute pores, and is white in colour. The sporophores are sometimes stalked but are usually sessile and a large number may be formed on one

palm. When many are present, they are usually arranged in overlapping series. The atypical form recorded by Thompson (1) is not often encountered.

As decay of the trunk progresses, the palm is weakened considerably and falls over. When cut open, a large core of chocolate-brown tissue is noticed at the base of the palm, with small patches of lemon coloured, soggy tissue interspersed and dark-brown bands in the periphery and extending up the stem. These have been termed "reaction zones" (18) and may represent areas where gum has been deposited. The symptoms on the roots are not easily discernible. Diseased roots are brittle and the cortex is light-brown. The tough, thick white bands reported by Petch (12) on tea roots in Ceylon have not been observed on oil palms.

Host-range

Venkatarayan (15) reported that 44 species belonging to 34 genera were attacked by this fungus. Of this number the family Leguminosae is represented by 11 genera.

Method of spread

Most observers were of the opinion that the disease was primarily a root disease. Butler (10) advised trenching and destruction of stumps and roots. Venkatarayan (13) thought that the disease on coconuts was primarily a root disease. 50 coconut palms affected by *G. lucidum* in Malaya were considered to be suffering from a root disease by Tempany (4). In Ceylon Petch reported that the fungus attacked the roots of tea plants (12). In Malaya both stem and root infections have been observed on oil palms by Thompson (5, 6). In Wales Island, off New Guinea, Bryce (19) advised removal and burning of stumps and roots and delimitation of infected areas by means of trenches. Bull (17) considered that on evidence available so far, infection occurs primarily via the roots. Several visits have been made by the author to estates where the disease has assumed serious proportions and in all cases the disease has been noted on the stem base only. A few treated cases of rot on the stem about 4-6′ from the ground have been seen, but it was not possible to attribute these cases to infection by *Ganoderma lucidum*, because the diseased tissue and sporophores had been removed and identification was therefore not possible. *Fomes noxius* causes a form of stem rot on oil palms and it is probable that these cases have been wrongly identified.

Materials and Methods

It is important to find out whether stem or root infection is operative under field conditions in order to be able to formulate proper control measures. The first step in such an investigation is to attempt artificial inoculation in the two positions, using inoculum which can be easily produced in the laboratory.

As early attempts to grow the fungus on a sterilized medium of sand and maize-meal did not succeed owing to poor mycelial growth, various supplements were added, until a fairly reasonable growth of mycelium was obtained. The final medium consisting of 300 gm. moist sand, 10 gm. maize-meal, 15 ml. of 10% malt extract with one gm. marmite, was packed in 24 oz. glass bottles, stoppered with cotton wool plugs and sterilized at 20 pounds pressure for 30 minutes. After a few days growth, the cultures had to be shaken up daily in order to break up large aggregations of medium and mycelium and prevent the culture from setting in a hard block which would have made withdrawal of the inoculum from the bottle difficult. Bacterial contamination of cultures was common and was probably due to insufficient length of sterilization. These contaminated cultures were discarded. Growth of the mycelium on the medium was still not profuse and therefore not wholly satisfactory.

Inoculations and Results

As it was considered unwise to introduce the fungus into a disease free area in production, where it might spread and become uncontrollable, the observation was carried out near the Federal Experiment Station, Kuala Lumpur on abandoned Deli palms planted more than 40 years before on quartzite soil.

Roots

When roots were inoculated a whole bottle of inoculum was buried at the stem base at a depth of about 1 foot and 3-5 roots were led into the bottle.

Stem

Stem inoculations were carried out by removing a one inch cube of stem tissue either at stem base or about 3 feet from the ground, filling the holes with the pure culture of the fungus and covering with a polythene square which was held in place by drawing pins. The area of the stem round the inoculum was kept damp for a week by spraying water on alternate days.

Out of 20 root inoculations carried out one palm is now exhibiting the first symptoms on the foliage, that is after 2 years. Out of 20 stem inoculation 3 were successful. First indications that an inoculation on the stem had been successful were observed 2 months later. These were the appearanc of white fungus specks, darkening of the stem and exudation of gum from the stem around inoculum (Plate I). The earliest appearance of a sporophore was about 9 months after intoculating. These were white and button-shaped at first (PlateII), but in a few days the fructifications changed to the flat form, with the upper side developing a reddish-brown shiny surface with a faint yellow-margin which gave way to white at the fringe (Plate III). The underside was white and covered with minute pores. No stalked fructifications were produced.

PLATE I

Infected stem base with Inoculated area arrowed.

PLATE II

Beginning of fructification formation.

PLATE III

A fully developed fructification.

PLATE IV

A fully developed fructification the stem, about 3 feet from the ground.

Symptoms on the fronds appeared last, about a year after inoculating and showed on the lowermost fronds first and later progressed up to the crown. Leaflets became yellow and dried up starting from the frond tip and dead fronds hung down in large numbers round the stem Death of palms ensued approximately 18 months from inoculation.

Discussion

As there had been considerable difficulty in the preparation of inoculum there is reason to doubt the suitability of inoculum used. Success in infecting roots of only one palm and stems of 3 palms was probably due to faulty technique rather than to any resistance possessed by palms. The observation has however shown that oil palm roots and stems are susceptible to infection, but from the results of this observation alone it is not possible to conclude which method is operative in the field. Further observations of diseased palms and the recording over several years of new outbreaks in an area where the disease is already established would help in solving this problem.

Exudation of gum from the stem as a result of stem inoculation can be taken as diagnostic of stem infection. This symptom is however rarely seen on naturally infected palm which is suggestive of infection taking place via the roots.

Acknowledgements

Thanks are due to R. N. Hilton of the Rubber Research Institution (Malaya) for useful criticisms in the preparation of this manuscript and to W. A. Sankey and Anthony Tan of this Department for the photographs.

References

(1) Thompson, A. (1931). Stem-rot of the Oil Palm in Malaya. Bull. Dep. Agr. S.S. & F.M.S., Sci. Ser. 6.
(2) Sharples, A. (1928). Malay Agr. J. 17: 294-303.
(3) Tempany, H. A. (1934). Ann. Rept. Dep. Agr. Mal: 62.
(4) Tempany, H. A. (1935). Ann. Rept. Dep. Agr. Mal: 63-65.
(5) Thompson, A. (1935). Dep. Agr. S.S. & F.M.S., Sp. Bull. Gen. Ser: 54, 1936.
(6) Thompson, A. (1937). Observations on Stem-rot of the Oil Palm. Dep. Agr. S.S. & F.M.S., Sp. Bull. Sci. Ser. 21: 1-28.
(7) Voelcker, O. J. (1950-51). Rep. Dep. Agr. Fed. Mal: 29.
(8) Heath, R. G. (1956). Ann. Rep. Dep. Agr. Fed. Mal: 47.
(9) Heath, R. G. (1957). Ann. Rep. Dep. Agr. Fed. Mal: 42.
(10) Butler, E. J. (1906). Some Diseases of Plams. Agr. J. Ind. 1: 299-310.
(11) Petch, T. (1910). Root Disease of the Coconut Palm. *Fomes lucidus* (Leys). Fr. Circ. & Agr. J. Roy. Bot. Gdns. Ceylon, Vol. IV: 323-336.

(12) Petch, T. (1923). The Diseases of the Tea Bush. MacMillan & Co., Limited, London.

(13) Venkatarayan, S. V. (1929). How to Distinguish between the Stem Bleeding and Anabe Roga of Coconuts. Mysore Agr. Cal: 13-17.

(14) Narasimhan, M. J. (1934). Adm. Rep. Agr. Dep. Mysore, 1932-33: 53-56.

(15) Venkatarayan, S. V. (1936). The Biology of *Ganoderma lucidum* on Areca and Coconut Palms. Phytopath. 26: 153-175.

(16) Dell, W. (1955). The infection of the Oil Palm in Sumatra. Abstract R.A.M. 34: 644.

(17) Wijbrans, J. R. (1955). Stem rot of the Oil Palm. Abstract R.A.M. 34: 450.

(18) Bull, R. A. (1954). A preliminary list of the Oil Palm Diseases encountered in Nigeria. J.W.A.I.F.O.R. 2: 53-93.

(19) Bryce, G. (1924). Coconut Diseases. Dep. Agr. New Guinea. Abstract R.A.M. 4: 279. 1925.

A NOTE ON INTESTINAL PARASITES IN SOME CHINESE CARPS

BY

JOSE I. FURTADO.

While discussing the economics of fish culture in commercial (Chinese) carp ponds in Malaya, certain observations and inferences have been documented on the subject of freshwater-fish parasitology in the annual report of the Tropical Fish Culture Research Institute, Malacca:—

> "The few observations so far carried out at the Institute suggest that fish from commercial carp ponds may be heavily infested with intestinal parasites. On the other hand those from ponds at the Institute, fertilized as they are with artificial fertilizers, appear to be comparatively free from infestation." (1).

In itself, this is an interesting inference in the field of freshwater-fish parasitology, because my limited observations on the subject indicate otherwise and, because any unqualified implication that artificial fertilizers play an important role in decreasing parasitic infestations in fish ponds cannot be accepted, wholly or partially, as being rational from our knowledge about local freshwater-fish parasites. Even though a pool of knowledge on the parasitology of local freshwater fishes is sadly lacking (some preliminary work on fish worms (3, 4) and on freshwater-fish helminths (5) has however been done), it is nevertheless worthwhile to discuss the two points that have arisen, namely the factual statement on the infestation of carps and the implication on the role of artificial fertilizers in decreasing parasitic infestation. Such a discussion may eliminate misunderstanding and may stimulate further study of this much-neglected aspect of parasitology, especially, since freshwater-fish culture is being extensively encouraged and is being practised in ever-increasing intensity.

Occurrence of Internal Parasites in Chinese Carps

The intestinal parasites most commonly found in freshwater-fishes are helminths, which include worms such as nematodes, digenetic trematodes, cestodes and acanthocephalns. In addition, protozoan parasites (such as *Eimeria* sp. which cause coccidiosis) also occur in the intestine. During the past two years, the alimentary tracts of fishes from commercial Chinese-carp ponds, as well as those from the fishponds at the Tropical Fish Culture Research Institute, Malacca, were examined specifically for helminth infestation when the opportunity availed itself. At least a dozen alimentary tracts from each of the two Chinese-carp species, *Ctenopharyngodon idellus* Cuv. (Chinese Grass Carp) and *Aristichthys*

nobilis (Big-head Carp), from commercial fishponds in Malacca (Malacca), Seremban (Negri Sembilan), Kuala Lumpur (Selangor), and Sembawang (Singapore), and more than a dozen alimentary tracts of Chinese Grass Carps from the above-mentioned institute, were examined. None of the fish examined were infested with intestinal helminth parasites. It would be interesting, therefore, to know more about the nature of the intestinal parasites which have been observed by the above-mentioned Institute in the fish from the commercial carp ponds. Investigations by Layman, Dogiel and Bykhovski, and several others, (quoted in (2)) on the incidence and intensity of parasitic infestation in the European Common Carp (*Cyprinus carpio* Linn.) show that cultured fish possess a parasitic fauna less rich-in-species than the wild fish, and that the cultured fish possess a greater proportion of parasitic species with direct development (i.e. without an intermediate host) than the wild fish. It is possible that the Chinese carps show similar trends.

Control of Parasitic Infestation

Control of parasitic (including helminthic) infestations may normally be attained in three ways: destruction of the parasite prior to reaching of the host, after reaching and prior to establishment within the host, or during its growth and reproduction after establishment within the host. In fish parasitology, "the methods of treatment include baths, the use of which frees the fish from its ectoparasites, various kinds of inoculation and an entire set of procedures designed to eradicate the disease in the pond : drying of the pond in summer, treatment of its bottom with lime, quarantine of single ponds or entire farms, extermination of wild fishes which might be carriers of disease agents, shooting of piscivorous birds, etc." (Bauer in (2)). There is no previous record of changes in water fertility being used to check paratitic infestation directly, although "another way in which parasitic diseases can be prevented or suppressed is that of building up the resistance of fishes by stimulating their growth rate and improving their condition" (A. V. Dogiel, quoted by Bauer in (2)). Nevertheless, any implication that non-artificial fertilizer is directly responsible for heavier intestinal infestation of parasites in commercial fishponds means, that there necessarily must be a parasite with indirect development which has a freshwater-fish as its definitive host and a mammal and/or bird as its intermediate host, or a parasite with direct development whose adult is common to man and fish. There is no record of such a parasite; on the other hand, however, there are indirectly developing parasites with the converse sequence of hosts, e.g. *Clonorchis* sp. (trematode), *Opisthorchis* sp. (trematode), *Diphyllobothrium* spp. (cestodes), *Contracoecum* spp. (nematodes). While the application of artificial fertilizers is undoubtedly more hygienic than usage of non-artificial fertilizers, and while it may stimulate a better algal growth in fishponds, there is no basis to believe that it has any significant effect indirectly reducing parasitic infestation in cultured fish.

A further point regarding the control of parasitic infestation : About three dozen Snakeheads, *Channa striata* (Bloch), from the fishponds at the above-mentioned Institute, were examined for intestinal helminth parasites. None of the (7) fish from the artificially-fertilized fishponds, harvested at six-monthly intervals, contained helminthic infestations; most of the other (28) fishes from artificially fertilized ponds which were harvested annually or after longer duration, contained intestinal helminths. This indicates that at least some helminthic infection can be controlled by a six-monthly (or more frequent) drainage of fishponds, and is in agreement with the findings of the Russian freshwater-fish paratisologists: "The depletion of parasite fauna of the pond-bred fishes is attributable to the lack of variety in the ichthyofauna of the ponds, the partial or complete absence of the intermediate hosts of many parasites and the periodical draining and drying of the ponds." (Bauer in (2)).

In conclusion, the healthy system of draining the fish ponds frequently, of exterminating wild fishes and other possible vectors of fish diseases, including piscivorous birds, and of drying the fishponds after draining is a much more reasonable and practicable method for limiting intestinal (and other) parasitic infestation.

References

1. Tropical Fish Culture Research Institute, Malacca, Report for 1960-1961, p. 31.

2. Dogiel, V. A., Petrushevski, G. K., and Polyanski, Yu. I. (Eds.) (1958) : Parasitology of Fishes. Leningrad University Press. Translated by Z. Kabata, 1961, 384 pp. Oliver & Boyd, London.

3. Sandosham, A. A. (1951) : A note on larval worms in fish. Proc. Alumi Assoc. King Edward VII Coll. Med. Singapore, 4 (2), 90-92.

4. Furtado, J. I. (1962) : "Fish Worms". Malayan Nature Journ., 16 ((1+2), 49-53.

5. Furtado, J. I. and Fernando, C. H. (In press) : Helminth parasites of Some Malayan freshwater fishes. Bull. national Museum, Singapore.

RESEARCH BRANCH LABORATORY EXTENSION

A major item of improvement in the facilities of the Research Branch has been the new building constructed to the north of the old Soil Science and Chemistry block at the departmental H.Q. in Swettenham Road, Kuala Lumpur. The new building, which is joined by a communicating bridge to the older block, supplies much needed additional working space for the Chemistry Division on the ground floor and for the Soil Science Division in the two upper stories.

The ground floor houses a pilot canning plant designed to undertake departmental canning investigations. Floor space is taken up, *inter alia*, by a deep freeze unit, an electrode steam boiler, a steam-jacketed jam-boiling vessel, a Mather & Platt No. 1 Canning Line, and a semi-automatic can-sealing machine, together with storage shelves and laboratory benches. The layout is flexible, and space can be easily made available for additional items of equipment. Spacious stores for the chemicals and apparatus of the whole Research Branch are also included on this floor.

The first floor contains a plant material preparations room fitted with drying ovens and grinding units where leaf samples are prepared for foliar analysis which is carried out in an adjoining laboratory in the old building. A soils museum which contains a large monolith collection of Malayan soil series is also installed on this floor and ample space is available to accommodate further additions to the reference collection which are expected from the expanding activities of the soil survey staff. Two offices for senior staff separate the Museum from a well equiped drawing office containing a large collection of maps and soil survey records. A feature of this office is a Saltzman projector which has been kindly presented to the department by the Canadian Government as a gift under the Colombo Plan. This instrument enables rapid and accurate reductions and enlargements to be made from maps or aerial photographs, and has proved invaluable in speeding up the draughting work involved in soil map compilation.

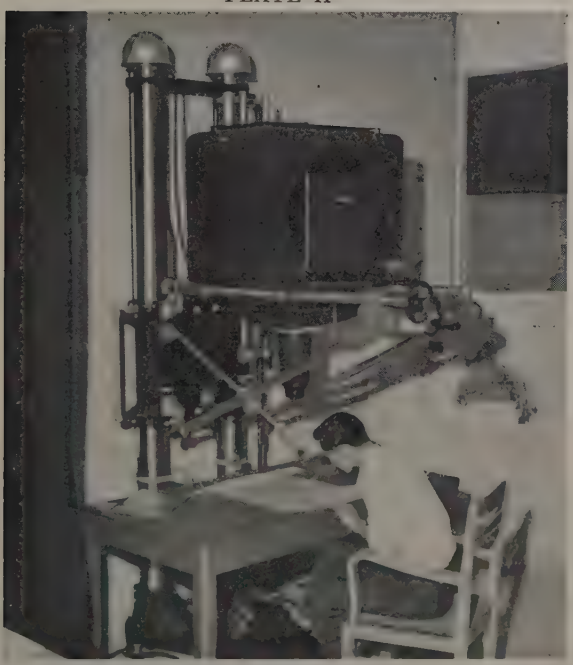
The top floor accommodates laboratories for trace element analysis based essentially on a spectrochemistry unit. This includes separate rooms for the digestion of plant and soil samples, the further chemical treatment of these samples, spectrograph room, dark room, microphotometer and other instruments room as well as an office.

The building, which was designed by Mr. David Rew D.A. (Glas.) A.R.I.B.A., and constructed by a private building contractor, is of reinforced concrete construction, and is pleasingly decorated, both inside and out, in a variety of colours suited to its sun bathed exposure in a silvan setting. The greater part of the building is comfortably air-conditioned.

PLATE I

Soil Science Division Extension, 1961.

PLATE II



Saltzman projector. Drawing Office.

Table I

AVERAGE MONTHLY PRICES PAID BY LOCAL DEALERS FOR SMALLHOLDERS' RUBBER, JANUARY TO DECEMBER, 1961.

(dollars per pikul*)

1961	Alor Star, Kedah			Seremban, Negri Sembilan			Johore Bahru, Johore		
	Jan.	Feb.	Mar.	Jan.	Feb.	Mar.	Jan.	Feb.	Mar.
Smoked Sheet									
No. 1	90.71	88.97	93.82	90.78	89.32	94.00	89.97	89.12	94.27
No. 3	87.18	86.47	90.63	87.80	87.08	90.93	87.69	87.37	91.72
1961	April	May	June	April	May	June	April	May	June
Smoked Sheet									
No. 1	97.18	96.93	92.46	97.24	96.36	92.07	97.59	96.33	92.25
No. 3	93.68	93.98	89.96	94.41	94.60	90.15	95.24	94.85	90.79
1961	July	August	Sept.	July	August	Sept.	July	August	Sept.
Smoked Sheet									
No. 1	92.71	93.83	93.50	92.87	94.29	93.51	93.20	93.99	93.37
No. 3	90.21	91.33	90.51	90.38	92.11	90.00	91.30	92.27	90.33
1961	Oct.	Nov.	Dec.	Oct.	Nov.	Dec.	Oct.	Nov.	Dec.
Smoked Sheet									
No. 1	89.70	83.40	86.85	90.42	84.06	87.15	90.14	84.04	87.50
No. 3	84.93	79.47	82.32	85.89	80.16	83.54	86.23	80.85	84.36

* 1 pikul = 133⅓ lb.

This table has been compiled from Statistics supplied by the Chief Statistician, Federation of Malaya.

Table II

RUBBER PRODUCTION FEDERATION OF MALAYA

(long tons, dry weight)

Month	Estates		Smallholdings (Estimated)		Total	
	1960	1961	1960	1961	1960	1961
January -	37,400	40,500	27,400	26,900	64,800	67,400
February -	31,800	30,800	22,500	26,000	54,300	56,800
March -	29,900	29,900	24,800	21,600	54,700	51,500
April -	28,000	27,700	19,000	21,000	47,000	48,700
May -	33,000	33,600	24,000	23,700	57,000	57,300
June -	34,000	36 200	24,000	26,300	58,000	62,500
July -	37,000	39,200	25,900	29,400	62,900	68,600
August -	36,100	38,200	25,900	27.700	62,000	65,700
September -	36,600	38,100	25,000	27,000	61,600	65,100
October -	37,000	39,800	25,900	26,200	62,900	66,000
November -	35,200	38,100	21,500	25,100	56,700	63,200
December -	39,100	39,300	27.500	26,600	66,600	65,900
Total -	415,100	43,200	293,500	307,500	708,500	738,700

This table has been compiled from statistics published by the Chief Statistician, Federation of Malaya.

Production on smallholdings (estates of less than 100 acres) is taken as the total of purchases from smallholders reported by licensed dealers.

Table III

AVERAGE PRICES PAID IN LONDON FOR TEA

(s.d. per lb.)

For the Week Ending	Malayan		Ceylon		Indonesian		India				African	
							Northern		Southern			
	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
6. 1.61	4	6.43	5	0.78	Nil		4	11.25	4	6.25	4	0.28
13. 1.61	4	10.46	4	11.41	3	5.78	4	9.93	4	5.73	4	0.66
20. 1.61	4	3.17	4	8.52	Nil		4	8.40	4	4.33	4	0.58
27. 1.61	4	5.10	4	6.90	Nil		4	7.59	4	3.48	3	11.18
3. 2.61	4	0.14	4	5.95	Nil		4	6.72	4	2.84	3	10.93
10. 2.61	4	0.39	4	5.80	Nil		4	6.43	4	1.93	4	1.45
17. 2.61	4	3.65	4	6.61	3	9.68	4	6.96	4	2.22	4	0.71
24. 2.61	4	3.39	4	7.15	Nil		4	7.86	4	1.78	4	1.02
3. 3.61	4	3.06	4	9.33	Nil		4	8.03	4	2.64	4	1.32
10. 3.61	4	2.91	4	9.37	Nil		4	7.87	4	3.27	4	2.09
17. 3.61	4	3.76	4	8.65	3	8.07	4	6.35	4	1.20	3	10.93
24. 3.61	4	1.89	4	8.46	Nil		4	5.91	3	11.92	3	8.82
30. 3.61	4	0.87	4	7.66	Nil		4	5.80	4	0.33	3	7.47
14. 4.61	4	0.12	4	7.92	3	10.59	4	5.00	4	0.56	3	6.64
21. 4.61	3	9.24	4	7.96	Nil		4	5.21	4	1.67	3	8.28
28. 4.61	3	11.31	4	9.58	Nil		4	5.75	4	2.86	3	6.90
5. 5.61	4	1.27	4	11.35	Nil		4	6.34	4	3.99	3	8.47
12. 5.61	4	1.52	5	0.75	Nil		4	5.80	4	4.49	3	7.76
19. 5.61	4	8.40	4	11.75	Nil		4	6.84	4	5.03	3	8.83
2. 6.61	4	3.18	4	10.28	Nil		4	6.96	4	3.47	3	8.83
9. 6.61	4	1.95	4	8.03	4	1.22	4	6.48	4	1.94	3	8.57
16. 6.61	4	2.88	4	6.04	Nil		4	5.99	4	0.46	3	7.48
23. 6.61	3	11.78	4	3.28	Nil		4	5.58	3	11.90	3	5.99
30. 6.61	3	10.36	4	2.99	Nil		4	7.07	3	11.84	3	7.18
7. 7.61	4	3.16	4	3.24	4	10.91	4	3 26	4	0.30	3	7.04
14. 7.61	3	11.01	4	2.77	3	2.95	4	1.40	3	10.92	3	6.31
21. 7.61	3	9.94	4	1.98	Nil		4	1.76	3	9.77	3	6.69
28. 7.61	3	8.44	4	2.20	Nil		4	2.20	3	9.71	3	6.17
4. 8.61	4	0.19	4	3.44	Nil		4	9.72	3	9.36	3	4.40
18. 8.61	3	9.03	4	5.28	Nil		4	6.44	3	8.88	3	3.72
25. 8.61	3	7.92	4	4.91	Nil		4	11.01	3	7.05	3	3.22
1. 9.61	3	7.79	4	5.15	Nil		4	11.82	3	5.28	3	2.51
8. 9.61	3	6 52	4	5.15	Nil		4	11.34	3	4.28	3	2.98
15. 9.61	3	7.56	4	4.84	2	10.45	5	1.34	3	4.29	3	1.94
22. 9.61	3	11.37	4	7.13	Nil		4	11.60	3	4.80	3	2.48
29. 9.61	3	9.27	4	8.78	Nil		5	0.99	3	4.64	3	3.36
6.10.61	4	1.11	4	8.90	3	6.31	5	2.40	3	5 01	3	5 28
13.10.61	3	4 88	4	10.44	Nil		5	0.86	3	5.01	3	6.04
20.10.61	3	7.99	4	10.93	3	6.15	4	11.87	3	5.50	3	5.90
27.10.61	Nil		4	11.31	Nil		4	9.97	3	5 29	3	4 24
3.11.61	3	9.72	5	2.12	Nil		4	8.88	3	6.06	3	1.58
10.11.61	3	4 45	5	2.25	3	9.11	4	10.81	3	6.23	3	3.48
17.11.61	3	5.28	5	0.11	Nil		4	8.80	3	4.65	3	7.48
24.11.61	3	9 94	4	11.14	Nil		4	6.59	3	5.35	3	1.44
1.12.61	4	2.19	5	0.08	Nil		4	3.83	3	4.09	3	1.32
8.12.61	3	9 02	4	9.67	Nil		4	4.08	3	3.33	3	2 11
15.12.61	3	9.50	4	9.43	Nil		**4**	**4.61**	3	3.62	3	2.17
22.12.61	3	2.54	4	7.78	2	9.12	4	4.00	3	3.62	3	5.85

* This table has been compiled from "Tea Market Reports" published by the Tea Brokers' Association of London.

Table IV

AVERAGE DEALERS' PRICES FOR DRIED LIBERICAN COFFEE BEANS GROWN IN SELANGOR*

(dollars per pikul †)

For the Week Ending	Klang	Kuala Langat
	$	$
7. 1.61	80.00	78.00
14. 1.61	80.00	75.00
21. 1.61	75.00	73.00
29. 1.61	75.00	70.00
4. 2.61	75.00	72.00
11. 2.61	75.00	72.00
18. 2.61	75.00	72.00
25. 2.61	78.00	75.00
4. 3.61	80.00	78.00
11. 3.61	80.00	80.00
18. 3.61	80.00	80.00
25. 3.61	75.00	75.00
1. 4.61	75.00	75.00
8. 4.61	80.00	75.00
15. 4.61	80.00	77.00
22. 4.61	80.00	78.00
29. 4.61	80.00	78.00
6. 5.61	75.00	75.00
13. 5.61	75.00	75.00
20. 5.61	75.00	75.00
27. 5.61	78.00	75.00
3. 6.61	78.00	75.00
10. 6.61	78.00	75.00
17. 6.61	80.00	75.00
24. 6.61	85.00	75.00
1. 7.61	85.00	80.00
8. 7.61	85.00	80.00
15. 7.61	95.00	88.00
25. 7.61	95.00	90.00
29. 7.61	100.00	98.00
5. 8.61	100.00	98.00
12. 8.61	95.00	95.00
19. 8.61	95.00	95.00
26. 8.61	90.00	95.00
2. 9.61	90.00	90.00
9. 9.61	95.00	90.00
16. 9.61	90.00	90.00
23. 9.61	90.00	90.00
30. 9.61	90.00	90.00
7.10.61	90.00	90.00
14.10.61	90.00	90.00
23.10.61	90.00	90.00
28.10.61	90.00	90.00
4.11.61	90.00	90.00
11.11.61	90.00	90.00
18.11.61	90.00	90.00
25.11.61	90.00	90.00
2 12.61	95.00	90.00
9.12.61	95.00	93.00
16.12.61	95.00	93.00
23.12.61	105.00	105.00
30.12.61	108.00	105.00

* These are not the prices paid to smallholders, who sell freshly harvested berries to dealers for processing.

† 1 pikul = 133⅓ lb.

Table V

PRODUCTION OF PALM OIL AND KERNELS AND PRICES OF PALM OIL

(long tons, as declared by estates)

Month	Production of Palm Oil (long tons)		Production of Palm Kernels (long tons)		Average Price per Ton of Palm Oil *		
	1960	1961	1960	1961	1961		
					£	s.	d.
January -	5,931	5,978	1,645	1,681	70	10	0
February -	7,232	5,644	2,012	1,625	72	7	0
March -	7,445	7,295	2,082	2,042	72	8	0
April -	7,638	6,813	2,030	1,805	72	11	2
May -	7,183	7,349	1,841	1,814	74	6	2
June -	9,127	8,700	2,352	2,038	76	2	8
July -	9,627	9,413	2,093	2,387	76	4	4
August -	8,007	8,585	2,101	2,211	76	15	0
September -	7,179	9,806	1,873	2,479	72	16	10
October -	6,827	9,218	1,782	2,306	71	6	2
November -	7,607	8,180	2,064	2,138	71	13	0
December -	6,540	6,367	1,797	1,701	70	8	3
Total -	90,343	93,348	23,672	24,227			

* F.O.B.

Table VI

PRODUCTION OF COPRA, COCONUT OIL AND COPRA CAKE
FEDERATION OF MALAYA

(tons)

Month	Copra Production						Coconut Oil Production *		Copra Cake (Poonac) Manufactured	
	Estates		Smallholdings (estimated)		Total		Oil Mills		Oil Mills	
	1960	1961	1960	1961	1960	1961	1960	1961	1960	1961
January	2,299	2,034	7,700	8,249	9,999	10,283	5,233	6,021	3,227	3,701
February	2,323	2,167	8,000	6,794	10,323	8,961	5,919	5,450	3,670	3,451
March	2,575	2,603	11,000	10,513	13,575	13,116	5,091	7,108	3,132	3,984
April	2,554	2,722	9,800	9,228	12,354	11,950	5,503	8,267	3,472	4,657
May	2,821	3,086	11,000	12,630	13,821	15,716	6,203	8,176	3,888	4,652
June	2,779	3,659	12,800	13,264	15,579	16,923	7,015	8,426	4,410	4,592
July	3,382	3,636	15,054	10,942	18,436	14,578	6,380	7,897	4,040	4,814
August	3,107	3,739	17,808	15,367	20,915	19,106	6,849	8,477	4,335	5,240
September	2,780	3,296	11,468	13,776	14,248	17,072	6,299	7,177	3,821	4,525
October	2,635	2,953	13,040	8,782	15,675	11,735	5,777	6,830	3,374	4,291
November	2,468	2,364	12,073	8,295	14,541	10,659	6,867	7,105	4,240	4,442
December	2,267	2,302	10,414	9,671	12,681	11,973	6,477	6,433	4,071	4,215
Total	31,990	34,561	140,157	127,711	172,147	162,272	73,613	87,367	45,680	52,564

Notes:—1. The above table has been compiled from statistics published by the Chief Statistician, Federation of Malaya.

2. Estate copra production and coconut oil production are as declared by estates and oil mills, respectively.

3. Statistics of smallholding coconut oil production are not available.

4. Smallholding copra production for commercial purposes is estimated from the formula: imports + estate stocks (opening) + estate production + smallholding production = exports + local oil mill consumption + estate stocks (closing).

* Includes both refined and crude oil.

Table VII

SINGAPORE PRICES OF VARIOUS AGRICULTURAL PRODUCTS

(dollars per pikul †)

Date	Copra, Sundried	Coconut Oil *	Pepper, F.A.Q. Muntok White	Pepper, Gen. Muntok White	Gambier, Cube	Sago Flour, Lingga	Tapioca Flour No. 1	Oilcake, Round
3. 1.61	26.25	42.50	255.00	265.00	46.00	9,63	13.00	13.25
9. 1.61	26.00	43.50	242.50	252.50	46.00	9,63	13.00	13.25
16. 1.61	26.50	44.00	240.00	250.00	46.00	9,63	13.00	12.15
23. 1.61	26.75	44.00	235.00	245.00	46.00	9.50	13.00	12.75
30. 1.61	27.00	45.00	232.50	242.50	46.00	9.50	13.00	13.50
6. 2.61	26.75	44.25	210.00	220.00	46.00	9.75	13.00	13.00
13. 2.61	26.75	45.00	132.50	142.50	46.00	9.63	13.00	13.50
20. 2.61	27.00	45.25	215.00	225.00	42.00	9.63	15.50	12.50
27. 2.61	27.00	45.50	200.00	210.00	42.00	9.63	15.50	12.50
6. 3.61	27.00	44.75	205.00	215.00	42.00	9.63	15.50	12.25
13. 3.61	26.88	44.50	195.00	205.00	42.00	9.63	15.50	12.50
21. 3.61	28.75	44.75	195.00	205.00	42.00	9.50	15.50	12.50
28. 3.61	27.00	44.50	180.00	190.00	42.00	9.38	15.50	12.50
4. 4.61	28.50	44.00	185.00	195.00	42.00	9.50	15.50	12.50
10. 4.61	26.88	43.00	180.00	190.00	42.00	9.25	15.50	12.50
17. 4.61	26.88	43.50	182.50	192.50	42.00	9.25	15.50	12.50
25. 4.61	26.88	43.50	200.00	210.00	42.00	9.25	15.50	12.50
2. 5.61	26.75	43.00	190.00	200.00	42.00	9.00	15.50	12.50
8. 5.61	28.38	43.00	190.00	200.00	42.00	8.75	15.50	13.50
15. 5.61	26.75	43.00	200.00	210.00	43.00	8.75	15.50	13.50
22. 5.61	26.25	42.00	192.50	202.50	41.00	8.75	15.75	13.50
29. 5.61	25.75	41.25	195.00	205.00	41.00	8.75	15.75	13.50
5. 6.61	25.75	41.00	195.00	205.00	40.00	8.75	15.75	14.50
12. 6.61	25.50	42.00	202.50	212.50	45.00	8.75	15.75	14.00
19. 6.61	25.75	40.50	187.50	197.50	42.00	8.75	15.75	14.00
26. 6.61	25.25	40.50	186.00	196.00	42.00	8.63	15.75	14.00
3. 7.61	26.00	41.75	180.00	190.00	41.00	8.68	16.00	13.00
10. 7.61	25.63	41.00	183.00	193.00	46.00	8.63	16.00	15.00
18. 7.61	26.50	40.50	182.00	192.00	42.00	8.63	16.00	15.00
24. 7.61	26.25	40.00	181.00	191.00	42.00	8.63	16.00	14.50
31. 7.61	26.25	40.50	181.00	191.00	43.00	8.63	16.00	14.50
8. 8.61	27.75	40.50	178.00	188.00	47.00	8.63	16.00	14.25
14. 8.61	27.50	40.00	176.00	186.00	47.00	8.63	16.00	14.50
21. 8.61	27.50	39.75	174.00	184.00	48.00	8.50	16.00	14.13
28. 8.61	27.38	39.75	177.00	187.00	47.00	8.63	16.00	14.50
4. 9.61	27.25	39.75	178.00	188.00	47.00	8.50	16.50	15.00
11. 9.61	25.75	39.00	174.00	184.00	46.00	8.50	16.00	14.50
18. 9.61	25.63	38.75	173.00	183.00	43.00	8.63	16.00	14.25
25. 9.61	25.50	38.25	178.00	188.00	45.00	8.50	14.50	14.50
2.10.61	26.00	37.75	177.00	187.00	41.00	8.38	13.00	14.50
9.10.61	26.25	38.25	175.00	185.00	43.00	8.25	13.00	14.50
16.10.61	24.75	38.25	171.00	181.00	41.00	8.25	13.00	14.50
24.10.61	25.00	38.00	161.00	171.00	42.00	8.00	13.00	14.50
30.10.61	24.63	37.63	159.00	169.00	41.00	7.88	13.00	14.50
6.11.61	24.63	38.00	161.00	171.00	41.00	7.88	13.00	14.50
13.11.61	25.50	37.88	170.00	180.00	41.00	7.75	13.00	14.50
20.11.61	24.75	37.75	162.00	172.00	42.00		13.00	15.50
27.11.61	24.75	38.25	164.00	174.00	39.00	8.00	13.00	14.50
4.12.61	24.75	37.50	161.00	171.00	39.00	8.00	13.00	14.50
11.12.61	25.25	38.00	164.00	174.00	39.00	8.00	15.50	16.50
18.12.61	24.88	38.50	166.00	176.00	39.00	8.13	13.00	16.50
28.12.61	25.50	40.50	166.00	176.00	39.00	8.13	13.00	16.50

The above prices are taken from the weekly reports of the Singapore Chamber of Commerce.

† 1 pikul = 133⅓ lb.

* F.O.B. in second-hand drums.

Table VIII

MALAYAN AGRICULTURAL EXPORTS,

JANUARY TO DECEMBER, 1961.‡

Product	Net Exports in Tons			
	* Year 1958	§ Year 1959	§ Year 1960	§ Year 1961
Arecanuts	4,938	6,941	2,178	6,076
Coconuts, fresh †	52,340	104,935	109,570	60,837
Coconut oil	67,483	27,641	27,378	49,148
Palm Oil	67,818	71,103	90,545	87,827
Pineapples, canned	41,417	27,119	32,823	44,133
Sago, flour	21,652	681	1,623	24,561
Tapioca, flake	350	122	628	558
Tapioca, pearl	3,333	1,765	12,498	13,191

‡ Statistics compiled from "Federation of Malaya, Statistics of External Trade", December, 1961.

* Figures for 1958 include Singapore.

§ Figures for 1959—1961 exclude Singapore.

† hundreds.

METEOROLOGICAL SUMMARY, MALAYA, JANUARY, 1961

Locality	Air Temperature Degrees Fahrenheit							Earth Temperature		Rainfall								Bright Sunshine		
	Means of			Absolute Extremes									Number of Days							
	A. Max.	B. Min.	Means of A and B	Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	At 1 foot ° F	At 4 feet ° F	Total		Most in a day Amt.	Precipitation .01 in. or more	Precipitation .04 in. or more	Thunderstorm	Fog morning obs.	Gale force 8 or more	Total	Daily Mean	Per cent.
										in.	mm.	in.						hr.	hr.	
Ipoh, Perak	91.2	71.4	81.3	95.8	68.0	82.2	75.2			8.67	220.2	4.25	12	10	2			228.55	7.37	
Kuala Lumpur, Selangor	89.4	72.0	80.7	94.4	68.5	77.3	74.6	83.2	84.5	7.30	185.4	3.78	12	7	4	1		197.35	6.37	
Sitiawan, Perak	87.9	71.5	79.7	91.2	66.0	83.8	74.4	82.6	83.5	4.94	125.5	1.29	14	11	1	2		220.70	7.12	
Kuantan, Pahang	82.7	70.5	76.6	86.4	67.0	76.1	74.9	78.1		25.40	645.2	6.82	21	17		2		141.85	4.57	
Bayan Lepas, Penang	88.3	73.2	80.7	91.2	69.6	81.7	75.9			8.30	224.8	2.85	8	7	5			249.20	8.04	
Malacca	87.3	72.4	79.9	91.8	69.9	77.8	75.0			2.59	65.8	1.57	9	8	1			185.05	5.97	
Mersing, Johore	82.0	73.1	77.5	85.4	69.6	74.6	77.2			21.36	542.5	4.38	20	18				164.20	18	
Alor Star, Kedah	89.1	71.2	80.1	93.7	67.2	82.3	74.0			2.62	66.5	0.66	8	7	1			261.60	8.44	
Kota Bharu, Kelantan	83.8	73.4	78.6	86.0	69.0	80.8	72.9	80.8	81.1	4.84	122.9	2.08	16	11	1	2		209.05	6.74	
K. Trengganu, Trengganu	82.8	72.6	77.7	84.8	68.7	80.1	77.0			4.66	118.4	1.49	20	15				176.95	5.71	
Singapore	85.3	73.4	79.3	90.2	71.5	77.9	76.2			6.05	153.7	1.06	13	12	2			166.20	5.36	
HILL STATION																				
Cameron Highlands, Tanah Rata, Pahang, (4750 ft.)	70.4	54.9	62.7	74.6	44.4	65.2	60.2			6.28	159.5	1.83	14	11				149.30	4.82	

Compiled from returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, FEBRUARY, 1961

Locality	Air Temperature Degrees Fahrenheit							Earth Temperature		Rainfall								Bright Sunshine		
	Means of		Means of A and B	Absolute Extremes				At 1 foot	At 4 feet	Total		Most in a day	Number of Days					Total	Daily Mean	Per cent.
	A. Max.	B. Min.		Highest Max.	Lowest Min.	Lowest Max.	Highest Min.					Amt.	Precipitation .01 in or more	Precipitation .04 in or more	Thunderstorm	Fog morning obs.	Gale force 8 or more			
	° F	° F						° F	° F	in.	mm.	in.						hr.	hr.	
Ipoh, Perak	94.2	72.9	83.5	92.6	68.8	87.5	76.3			3.71	94.2	0.88	12	10	3			223.20	7.97	
Kuala Lumpur, Selangor	92.1	72.9	82.5	94.9	68.8	85.2	76.7	84.7	85.3	4.20	106.7	1.33	14	11	6	3		198.55	7.09	
Sitiawan, Perak	89.9	72.5	81.2	92.9	68.2	85.9	75.1	84.0	84.8	5.10	129.5	2.03	15	11	5	3		230.75	8.24	
Kuantan, Pahang	85.9	70.6	78.3	88.8	65.0	81.3	74.5	80.1		7.84	199.1	1.90	13	12				177.90	6.35	
Bayan Lepas, Penang	89.5	74.1	81.8	92.3	70.9	83.6	77.8			2.75	69.9	1.75	9	7	6			228.95	8.18	
Malacca	89.7	73.0	81.3	92.0	70.5	82.3	75.2			3.38	85.9	1.62	10	8	1			182.15	6.51	
Mersing, Johore	83.5	74.6	79.1	85.9	71.0	79.5	77.3			3.66	93.0	1.38	12	10	1			189.45	6.77	
Alor Star, Kedah	92.8	72.0	82.4	94.8	66.5	88.0	75.4			2.96	75.2	1.41	7	6	2			253.60	9.06	
Kota Bharu, Kelantan	85.8	73.1	79.5	88.3	67.8	82.0	77.6	84.9	83.9	4.49	114.0	2.98	8	6				232.95	8.32	
K. Trengganu, Trengganu	84.6	72.6	78.6	86.5	67.5	81.7	77.2			4.55	115.6	2.14	8	5		2		218.95	7.82	
Singapore	87.8	74.4	81.1	91.9	71.1	80.3	77.0			5.25	133.4	1.90	10	10	4	1		162.20	5.79	
HILL STATION																				
Cameron Highlands, Tanah Rata, Pahang, (4750 ft.)	73.0	54.6	63.8	79.0	44.8	66.8	61.0			5.91	150.1	1.02	14	13				161.55	5.77	

Compiled from returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, MARCH, 1961

Locality	Air Temperature Degrees Fahrenheit							Earth Temperature		Rainfall								Bright Sunshine		
	Means of		Means of A and B	Absolute Extremes				At 1 foot	At 4 feet	Total		Most in a day	Number of Days					Total	Daily Mean	Per cent.
	A. Max.	B. Min.		Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	°F	°F			Amt.	Precipitation .01 in. or more	Precipitation .04 in. or more	Thunderstorm	Fog morning obs.	Gale force 8 or more			
										in.	mm.	in.						hr.	hr.	
Ipoh, Perak	92.8	73.3	83.1	95.6	72.0	89.1	76.4			10.40	264.2	3.99	19	17	12			213.45	6.89	
Kuala Lumpur, Selangor	92.1	74.2	83.1	95.2	71.2	87.4	77.2	84.9	85.8	11.07	281.2	2.15	24	20	15	9		214.80	6.93	
Sitiawan, Perak	88.9	73.4	81.1	92.0	71.2	84.2	76.8	84.3	84.9	9.39	238.5	2.82	17	16	5			199.05	6.42	
Kuantan, Pahang	88.3	71.3	79.8	93.4	65.8	80.7	75.6	82.5		8.35	212.1	2.36	14	14	5	2		214.45	6.92	
Bayan Lepas, Penang	88.8	74.6	81.7	91.4	71.8	86.1	77.0			7.75	196.9	1.56	17	15	16			224.00	7.23	
Malacca	89.9	73.3	81.6	94.1	71.0	85.3	76.0			5.40	137.2	1.39	15	14	7			225.05	7.26	
Mersing, Johore	86.9	72.6	79.7	91.2	70.9	79.6	78.4			7.20	182.9	2.34	13	12	3			236.85	7.64	
Alor Star, Kedah	92.7	73.6	83.1	94.4	70.0	90.4	77.3			4.33	110.0	1.24	12	10	8			263.35	8.49	
Kota Bharu, Kelantan	88.3	73.7	81.0	91.9	69.6	83.9	76.1	87.2	86.3	2.51	63.8	0.74	9	7		2		257.55	8.31	
K. Trengganu, Trengganu	87.9	73.5	80.7	91.0	69.5	88.8	79.1			3.96	100.6	2.04	13	8	1	1		152.25	8.20	
Singapore	88.6	74.7	81.7	92.9	72.0	82.9	77.0			11.78	299.2	4.68	14	10	15	1		195.15	6.29	
HILL STATION																				
Cameron Highlands, Tanah Rata, Pahang. (4750 ft.)	73.3	52.7	63.0	76.8	44.6	67.8	62.0			6.99	177.5	1.36	23	17				148.15	4.78	

Compiled from returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, APRIL, 1961

Locality	Air Temperature Degrees Fahrenheit							Earth Temperature		Rainfall								Bright Sunshine		
	Means of		Means of A and B	Absolute Extremes				At 1 foot	At 4 feet	Total		Most in a day	Number of Days					Total	Daily Mean	Per cent.
	A. Max.	B. Min.		Highest Max.	Lowest Min.	Lowest Max.	Highest Min.					Amt.	Precipitation .01 in. or more	Precipitation .04 in. or more	Thunderstorm	Fog morning obs.	Gale force 8 or more			
								o F	o F	in.	mm.	in.						hr.	hr.	
Ipoh, Perak	92.8	73.9	83.8	96.0	71.5	88.9	75.6			9.79	248.7	3.62	21	18	7			218.00	7.27	
Kuala Lumpur, Selangor	91.2	74.8	83.0	94.6	71.1	82.4	77.4	85.5	86.2	7.60	193.0	1.16	21	17	15	1		199.30	6.64	
Sitiawan, Perak	89.4	73.8	81.6	91.9	71.2	84.9	75.7	83.7	83.9	9.16	232.7	2.38	19	18	10	3		214.55	7.15	
Kuantan, Pahang	88.9	73.2	81.0	93.0	69.7	84.2	75.4	83.1		12.03	305.6	2.58	20	18	16	10		174.65	5.82	
Bayan Lepas, Penang	89.1	75.5	82.3	92.9	72.3	86.3	77.4			8.50	215.9	1.99	20	17	17			217.50	7.25	
Malacca	89.1	74.5	81.8	92.2	72.5	83.5	76.9			9.71	246.6	2.09	21	17	18			192.05	6.40	
Mersing, Johore	88.5	72.9	80.7	91.9	70.6	85.0	75.1			8.52	216.2	1.63	15	15	8			206.75	6.89	
Alor Star, Kedah	91.6	75.0	83.3	96.2	72.5	86.2	78.0			7.21	183.1	1.91	22	16	10			231.80	7.73	
Kota Bharu, Kelantan	88.6	75.3	81.9	92.0	73.0	79.5	79.0	88.4	88.1	4.56	115.6	1.62	10	9	3	1		224.35	7.48	
K. Trengganu, Trengganu	88.6	74.5	81.5	91.8	72.3	81.8	78.7			3.84	97.5	1.10	13	8	1	1		228.45	7.61	
Singapore	89.1	75.5	82.3	92.2	73.3	85.8	77.6			5.44	138.2	1.38	18	14	15			160.95	5.37	
HILL STATION																				
Cameron Highlands, Tanah Rata, Pahang. (4750 ft.)	74.6	55.1	64.9	78.2	45.0	71.0	62.4			13.37	339.6	1.71	23	21				159.40	5.31	

Compiled from returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, MAY, 1961

Locality	Air Temperature Degrees Fahrenheit							Earth Temperature		Rainfall									Bright Sunshine		
	Means of		Means of A and B	Absolute Extremes				At 1 foot	At 4 feet	Total		Most in a day	Number of Days						Total	Daily Mean	Per cent.
	A. Max.	B. Min.		Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	°F	°F			Amt.	Precipitation .01 in or more	Precipitation .04 in or more	Thunderstorm	Fog morning obs.	Gale force 8 or more				
										in.	mm.	in.							hr.	hr.	
Ipoh, Perak	93.7	74.3	84.0	98.7	71.4	88.5	78.0			4.31	109.2	2.25	11	8	4				230.00	7.42	
Kuala Lumpur, Selangor	91.8	74.7	83.3	96.0	73.0	87.4	77.9	85.7	86.3	3.52	89.4	1.96	10	10	7	1			219.65	7.09	
Sitiawan, Perak	90.4	73.9	82.1	93.2	72.0	87.1	76.0	85.3	86.0	1.48	37.6	0.46	9	6	1				229.45	7.40	
Kuantan, Pahang	90.1	73.5	81.8	93.2	70.8	83.2	76.5	84.0		9.27	235.5	2.68	16	14	16	4			190.55	6.15	
Bayan Lepas, Penang	89.3	75.6	82.5	92.0	71.8	84.7	82.5			6.80	172.7	2.71	14	11	10				207.80	6.70	
Malacca	89.0	74.6	81.8	91.5	72.8	85.0	77.0			4.90	124.5	1.03	16	9	11				220.60	7.12	
Mersing, Johore	89.7	73.7	81.7	92.8	71.4	86.2	75.1			6.36	161.5	1.41	16	14	8				221.55	7.15	
Alor Star, Kedah	90.1	75.8	82.9	92.8	72.4	83.0	78.0			7.36	186.9	1.80	18	15	4	1			236.45	7.63	
Kota Bharu, Kelantan	89.9	75.9	82.9	95.0	73.2	84.9	79.0	87.9	87.9	1.46	37.1	0.35	9	9	6				232.85	7.51	
K. Trengganu, Trengganu	89.7	75.0	82.3	92.4	72.5	85.5	78.0			1.29	32.8	0.50	7	5	5				228.80	7.38	
Singapore	89.3	75.6	82.5	92.2	71.8	85.2	80.2			5.39	136.9	1.83	16	11	13	2			181.35	5.85	
HILL STATION																					
Cameron Highlands, Tanah Rata, Pahang, (4750 ft.)	75.1	55.9	65.5	78.2	48.8	72.2	62.2			5.65	143.5	0.76	19						199.56	6.44	

Compiled from returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, JUNE, 1961

Locality	Air Temperature Degrees Fahrenheit							Earth Temperature		Rainfall								Bright Sunshine		
	Means of			Absolute Extremes				At 1 foot	At 4 feet	Total		Most in a day	Number of Days					Total	Daily Mean	Per cent.
	A. Max.	B. Min.	Means of A and B	Highest Max.	Lowest Min.	Lowest Max.	Highest Min.					Amt.	Precipitation .01 in. or more	Precipitation .04 in. or more	Thunderstorm	Fog morning obs.	Gale force 8 or more			
								o F	o F	in.	mm.	in.						hr.	hr.	
Ipoh, Perak	92.3	73.0	82.7	96.9	70.2	82.0	76.8			4.98	126.5	2.45	12	8	3			211.75	7.06	
Kuala Lumpur, Selangor	90.3	73.7	82.0	94.1	70.8	84.8	76.4	84.7	86.1	5.44	138.2	1.34	12	10	8			196.45	6.55	
Sitiawan, Perak	89.7	72.5	80.6	92.8	69.5	81.9	75.6	84.7	86.0	3.40	86.4	1.29	10	7	4	1		205.40	6.85	
Kuantan, Pahang	89.4	72.2	80.8	92.0	69.2	82.9	76.2	83.1		11.87	301.5	3.30	11	10	8			197.45	6.58	
Bayan Lepas, Penang	88.0	74.1	81.1	90.9	69.7	80.4	78.2			6.97	177.0	1.30	13	12	6			188.45	6.28	
Malacca	87.2	72.9	80.1	90.0	90.4	83.2	74.8			11.74	298.2	4.06	12	12	10			202.75	6.76	
Mersing, Johore	88.5	72.3	80.4	91.8	70.0	80.6	74.2			3.67	93.2	1.27	15	13	10			206.90	6.90	
Alor Star, Kedah	88.5	74.4	81.5	92.3	72.1	81.3	72.2			8.77	222.8	3.03	15	14	3			210.05	7.00	
Kota Bharu, Kelantan	89.7	74.4	82.1	93.0	72.2	83.6	76.6	88.3	88.4	3.31	84.1	1.88	8	6	2			205.60	6.85	
K. Trengganu, Trengganu	88.9	73.5	81.2	93.0	71.1	79.3	75.8			5.24	133.1	2.23	12	6	5			195.80	6.53	
Singapore	87.9	75.1	81.5	91.0	72.1	80.4	50.3			4.71	119.6	1.21	14	9	9	1		181.70	6.06	
HILL STATION																				
Cameron Highlands, Tanah Rata, Pahang. (4750 ft.)	72.8	53.7	63.3	75.4	47.6	69.8	59.0			4.30	109.2	1.34	15	13				166.35	5.55	

Compiled from returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, JULY, 1961

Locality	Air Temperature Degrees Fahrenheit							Earth Temperature		Rainfall								Bright Sunshine		
	Means of		Means of A and B	Absolute Extremes				At 1 foot	At 4 feet	Total		Most in a day	Number of Days					Total	Daily Mean	Per cent.
	A. Max.	B. Min.		Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	° F	° F			Amt.	Precipitation .01 in. or more	Precipitation .04 in. or more	Thunderstorm	Fog morning obs.	Gale force 8 or more			
										in.	mm.	in.						hr.	hr.	
Ipoh, Perak	92.7	71.7	82.2	97.0	69.0	88.1	74.9			7.62	193.5	3.61	12	10	6			236.50	7.63	
Kuala Lumpur, Selangor	71.1	72.3	81.7	94.9	70.0	86.8	75.0	83.9	85.4	4.32	109.7	0.82	12	11	8	1		235.75	7.60	
Sitiawan, Perak	90.0	71.1	80.5	92.2	68.2	86.3	74.3	84.7	86.0	4.61	117.1	2.76	7	4	4			239.35	7.72	
Kuantan, Pahang	89.7	71.2	80.5	93.2	66.1	82.3	74.1	83.5		4.06	103.1	1.19	11	9	10	4		231.30	7.46	
Bayan Lepas, Penang	87.5	72.7	80.1	90.9	69.9	82.2	75.3			5.99	152.1	1.26	15	14	13			213.25	6.88	
Malacca	87.3	72.2	79.7	89.1	69.0	82.2	74.5			2.86	72.6	1.32	12	9	9			228.90	7.38	
Mersing, Johore	87.2	72.0	79.6	89.8	69.0	78.5	76.1			4.27	108.5	1.34	12	9	5			235.35	7.59	
Alor Star, Kedah	88.5	73.7	81.1	90.8	71.7	81.4	75.8			4.49	114.0	1.06	11	11	5			236.95	7.45	
Kota Bharu, Kelantan	89.1	73.7	81.4	92.3	71.4	84.3	75.7	87.0	87.9	3.81	96.8	1.32	10	9	7	1		257.50	8.31	
K. Trengganu, Trengganu	88.8	73.3	81.1	91.8	70.2	82.7	76.1			7.43	188.7	3.21	10	8	4	1		253.30	8.17	
Singapore	88.2	74.9	81.5	91.0	70.4	82.1	79.7			4.72	119.9	1.38	11	7	9	4		223.35	7.20	
HILL STATION																				
Cameron Highlands, Tanah Rata, Pahang. (4750 ft.)	73.4			77.8		68.5				6.99	177.3	1.60	15	14				193.75	6.25	

Compiled from returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, AUGUST, 1961

Locality	Air Temperature Degrees Fahrenheit							Earth Temperature		Rainfall								Bright Sunshine		
	Means of			Absolute Extremes				At 1 foot	At 4 feet	Total		Most in a day	Number of Days					Total	Daily Mean	Per cent.
	A. Max.	B. Min.	Means of A and B	Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	o F	o F			Amt.	Precipitation .01 in. or more	Precipitation .04 in. or more	Thunderstorm	Fog morning obs.	Gale force 8 or more			
										in.	mm.	in.						hr.	hr.	
Ipoh, Perak	91.7	72.9	82.3	94.7	69.5	85.1	76.2			4.15	105.4	1.81	11	10	5			213.20	6.88	
Kuala Lumpur, Selangor	90.3	73.1	81.7	94.4	69.0	86.4	75.9	83.1	84.8	5.24	133.1	1.73	11	8	6			206.25	6.65	
Sitiawan, Perak	88.6	72.0	80.3	90.5	70.0	84.1	75.1	84.1	85.4	3.97	100.8	1.25	10	8	11			209.20	6.75	
Kuantan, Pahang	89.0	72.0	80.5	91.3	66.2	82.2	75.4			7.40	188.0	1.90	12	10	13	6		187.85	6.06	
Bayan Lepas, Penang	87.7	73.7	80.7	90.2	69.6	80.0	78.2			6.44	163.6	2.07	8	8	7			201.45	6.50	
Malacca	87.1	72.4	79.7	89.9	68.5	82.7	74.1			4.33	110.0	1.22	10	9	7	2		210.85	6.80	
Mersing, Johore	87.6	71.8	79.7	91.6	69.7	80.7	75.0			5.58	141.7	1.16	16	16	8			224.30	7.23	
Alor Star, Kedah	88.8	74.6	81.7	92.2	71.0	79.8	76.6			4.51	114.3	1.36	10	7	4			212.35	6.85	
Kota Bharu, Kelantan	88.8	74.1	81.5	91.5	71.2	85.6	77.1	86.6	86.9	2.50	63.5	1.07	9	6	11			209.40	6.95	
K. Trengganu, Trengganu	87.9	73.0	80.5	90.1	69.7	84.8	76.0			8.57	217.7	2.82	12	9	4	2		211.80	6.83	
Singapore	88.0	75.1	81.5	91.8	70.2	82.0	77.6			2.60	66.0	1.01	5	4	5	4		211.40	6.82	
HILL STATION																				
Cameron Highlands, Tanah Rata, Pahang. (4750 ft.)		54.7								4.66	118.4	0.85	15	13				155.40	5.01	

Compiled from returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, SEPTEMBER, 1961

Locality	Air Temperature Degrees Fahrenheit							Earth Temperature		Rainfall									Bright Sunshine		
	Means of		Means of A and B	Absolute Extremes				At 1 foot	At 4 feet	Total		Most in a day	Number of Days						Total	Daily Mean	Per cent.
	A. Max.	B. Min.		Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	° F	° F			Amt.	Precipitation .01 in. or more	Precipitation .04 in. or more	Thunderstorm	Fog morning obs.	Gale force 8 or more				
										in.	mm.	in.							hr.	hr.	
Ipoh, Perak	90.2	71.8	81.0	93.0	68.6	87.2	74.8			6.33	160.8	0.93	18	15	7				184.65	6.15	
Kuala Lumpur, Selangor	89.8	72.5	81.1	92.1	69.8	85.8	75.5	83.0	84.7	8.00	203.2	2.19	19	16	15	2			170.15	5.67	
Sitiawan, Perak	88.2	71.7	79.9	90.4	69.1	84.0	73.3	84.1	85.2	5.47	138.9	2.48	17	14	8	1			176.40	5.88	
Kuantan, Pahang	89.1	70.8	79.9	91.3	67.2	84.2	74.1	83.1		8.39	213.1	1.93	15	11	12	3			185.10	6.17	
Bayan Lepas, Penang	86.9	73.5	80.2	89.6	71.1	83.1	76.2			8.00	203.2	2.11	17	15	16				178.45	5.95	
Malacca	88.0	71.7	79.9	90.9	68.4	82.8	75.8			5.34	135.6	2.67	7	6	6	2			202.30	6.74	
Mersing, Johore	87.7	71.7	79.7	91.0	69.4	80.4	73.7			8.27	210.1	3.17	10	10	9				215.10	7.17	
Alor Star, Kedah	87.0	73.7	80.3	91.0	71.3	78.4	76.3			13.83	351.3	2.72	19	15	5				181.55	6.05	
Kota Bharu, Kelantan	88.8	73.1	80.9	90.8	71.0	85.6	76.0	86.7	87.6	4.28	108.7	1.14	13	11	11				229.05	7.63	
K. Trengganu, Trengganu	88.1	72.4	80.3	90.1	70.8	83.7	75.1			2.74	69.6	0.88	13	9	2				229.50	7.65	
Singapore	89.2	74.3	81.7	92.8	71.4	82.2	79.4			3.43	87.1	1.18	8	6	7	4			196.80	6.56	
HILL STATION																					
Cameron Highlands, Tanah Rata, Pahang, (4750 ft.)		54.8								12.87	326.9	2.09	24	23					114.75	3.83	

Compiled from returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, OCTOBER, 1961

Locality	Air Temperature Degrees Fahrenheit							Earth Temperature		Rainfall									Bright Sunshine		
	Means of			Absolute Extremes				At 1 foot	At 4 feet	Total		Most in a day	Number of Days						Total	Daily Mean	Per cent.
	A. Max.	B. Min.	Means of A and B	Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	°F	°F			Amt.	Precipitation .01 in. or more	Precipitation .04 in. or more	Thunderstorm	Fog morning obs.	Gale force 8 or more				
										in.	mm.	in.							hr.	hr.	
Ipoh, Perak	89.2	71.7	80.5	93.9	69.9	79.1	74.4			7.08	138.1	1.75	18	14	3				166.20	5.36	
Kuala Lumpur, Selangor	89.4	73.4	81.4	93.5	71.0	77.6	76.0	82.9	84.4	10.20	259.1	3.23	14	14	8	3			144.25	4.65	
Sitiawan, Perak	86.4	71.8	79.1	90.2	70.0	76.7	74.0	82.7	84.3	10.82	274.8	2.08	20	19	7				151.30	4.88	
Kuantan, Pahang	88.5	71.1	79.8	92.3	68.3	84.0	74.9	82.6		6.63	168.4	1.73	12	10	7	10			167.70	5.41	
Bayan Lepas, Penang	86.1	73.2	79.6	89.0	70.7	78.5	74.9			14.66	372.4	3.26	20	19	17				159.55	5.15	
Malacca	87.9	72.0	79.9	90.5	68.3	81.7	75.0			2.30	58.4	0.55	15	12	7	2			151.15	4.87	
Mersing, Johore	87.3	71.5	79.4	92.0	69.2	80.6	73.8			6.87	174.5	1.61	13	13	8				181.55	5.86	
Alor Star, Kedah	87.0	73.2	80.1	90.3	71.4	80.7	75.4			13.04	331.2	4.79	21	19	8				166.80	5.38	
Kota Bharu, Kelantan	86.3	73.5	79.9	89.1	70.0	83.1	75.0	83.1	85.0	13.01	330.5	3.14	20	17	12	2			185.20	5.97	
K. Trengganu, Trengganu	86.2	72.9	79.5	89.1	71.2	81.0	74.3			8.77	222.8	2.05	15	12	8				178.10	5.75	
Singapore	89.2	74.0	81.6	92.2	70.6	85.2	77.2			2.07	52.6	0.93	7	6	7	8			148.80	4.80	
HILL STATION																					
Cameron Highlands, Tanah Rata, Pahang. (4750 ft.)	71.7	55.8	63.7	75.4	49.0	66.0	60.4			13.79	350.2	2.30	25	25					938.00	3.03	

Compiled from returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, NOVEMBER, 1961

Locality	Air Temperature Degrees Fahrenheit							Earth Temperature		Rainfall								Bright Sunshine		
	Means of		Means of A and B	Absolute Extremes				At 1 foot	At 4 feet	Total		Most in a day	Number of Days					Total	Daily Mean	Per cent.
	A. Max.	B. Min.		Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	° F	° F			Amt.	Precipitation .01 in or more	Precipitation .04 in or more	Thunderstorm	Fog morning obs.	Gale force 8 or more			
										in.	mm.	in.						hr.	hr.	
Ipoh, Perak	89.8	72.2	81.0	93.1	70.4	84.2	74.2			9.86	250.4	1.68	19	19	12			200.90	6.70	
Kuala Lumpur, Selangor	90.4	73.3	81.9	94.3	72.0	84.2	75.4	83.3	84.5	13.51	343.2	3.19	21	18	17	7		189.00	6.30	
Sitiawan, Perak	88.0	72.5	80.3	90.2	71.1	84.9	74.0	83.7	84.5	8.31	211.1	1.33	23	17	10	3		202.30	6.74	
Kuantan, Pahang	85.2	71.1	78.1	89.0	68.3	78.3	73.8	81.6		7.39	187.7	1.04	20	19	6	3		165.45	5.51	
Bayan Lepas, Penang	87.7	73.6	80.7	80.3	70.1	84.1	75.1			6.49	164.4	1.12	22	19	20			217.25	7.24	
Malacca	87.9	72.7	80.3	91.6	70.5	81.9	74.6			7.44	189.0	1.30	25	22	14			187.85	6.26	
Mersing, Johore	86.0	71.9	78.9	90.1	69.8	76.4	74.1			18.19	462.0	3.25	23	21	6			215.20	7.17	
Alor Star, Kedah	89.4	73.5	81.5	92.6	71.5	81.1	75.2			4.80	121.9	0.90	17	14	8			216.25	7.21	
Kota Bharu, Kelantan	83.1	73.8	78.5	87.2	71.6	75.2	75.8	79.6	80.6	41.44	1041.4	9.02	28	27	11	1		124.35	4.15	
K. Trengganu, Trengganu	82.8	73.3	78.1	86.5	71.2	75.8	75.2			36.84	935.7	5.30	30	29	2			134.95	4.50	
Singapore	87.8	73.8	80.8	91.1	71.2	79.7	75.0			8.65	219.7	2.30	19	15	14			180.00	6.00	
HILL STATION																				
Cameron Highlands, Tanah Rata, Pahang, (4750 ft.)	72.6	57.5	65.1	79.4	51.2	68.0	62.0			9.84	249.9	2.13	23	20				134.10	4.47	

Compiled from returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, DECEMBER, 1961

Locality	Air Temperature Degrees Fahrenheit							Earth Temperature		Rainfall								Bright Sunshine		
	Means of		Means of A and B	Absolute Extremes				At 1 foot	At 4 feet	Total		Most in a day	Number of Days					Total	Daily Mean	Per cent.
	A. Max.	B. Min.		Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	° F	° F			Amt.	Precipitation .01 in. or more	Precipitation .04 in. or more	Thunderstorm	Fog morning obs.	Gale force 8 or more			
										in.	mm.	in.						hr.	hr.	
Ipoh, Perak	88.6	72.1	80.3	92.1	67.5	85.0	74.0			6.66	169.2	2.52	17	16	5			154.95	5.00	
Kuala Lumpur, Selangor	89.7	73.7	81.9	93.4	70.8	84.8	76.2	83.4	84.7	10.83	275.1	1.77	22	20	13	8		161.35	5.20	
Sitiawan, Perak	87.1	72.5	79.8	90.4	70.2	80.0	74.2	83.7	84.7	6.13	155.7	2.95	17	14	1	6		157.65	5.09	
Kuantan, Pahang	82.8	71.7	77.3	90.2	68.2	75.8	74.0	79.2		14.69	373.1	4.00	26	23	4			74.85	2.41	
Bayan Lepas, Penang	87.3	74.1	80.7	89.7	71.1	84.9	76.5			5.06	128.5	1.56	15	12	9			189.05	6.10	
Malacca	87.5	72.9	80.1	90.1	69.3	83.2	74.6			5.97	151.6	1.40	19	11	8			157.65	5.05	
Mersing, Johore	81.9	72.4	77.1	87.0	76.1	71.0	74.4			26.18	665.0	4.24	27	27	1			105.65	3.41	
Alor Star, Kedah	87.7	72.4	80.1	90.7	70.2	82.0	74.4			8.50	215.9	1.52	13	11	3			158.65	5.12	
Kota Bharu, Kelantan	82.3	73.8	78.1	85.6	71.2	75.2	77.0	77.7	79.0	37.47	951.7	6.54	27	25	1			83.40	2.69	
K. Trengganu, Trengganu	81.4	73.5	77.5	84.5	71.3	76.2	75.3			31.74	806.2	6.27	30	27	2			70.30	2.27	
Singapore	86.0	73.6	79.8	90.8	72.0	78.9	75.9			11.23	285.2	2.68	20	17	11	1		130.50	4.21	
HILL STATION																				
Cameron Highlands, Tanah Rata, Pahang, (4750 ft.)	70.8	58.1	64.5	74.8	52.0	67.4	61.4			7.56	192.0	1.44	24	20				73.90	2.38	

Compiled from returns supplied by the Malayan Meteorological Service.

Wiping makes doubly sure...

The spread of lallang demands vigorous measures for control. Spraying and wiping with Shell Lallang Oils will destroy lallang and render ground ready for replanting. This is the surest and safest method. Whatever the method employed, it is necessary to spray and wipe with Shell Lallang Oils to complete the destruction. Make *sure* of control by spraying and *doubly sure* of eradication by wiping with . . .

SHELL LALLANG OILS

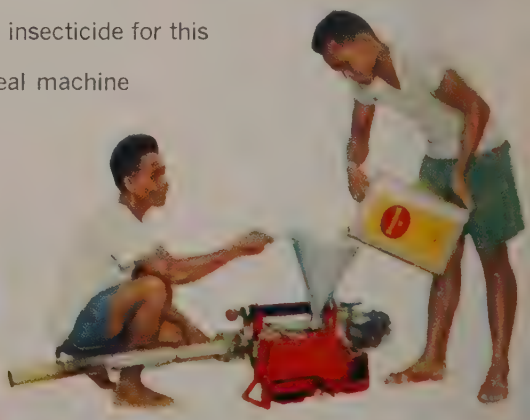
SHELL

KILLER FOG

swingfog

a portable pulse-jet fogging machine, which is extremely easy to use, and which is already used all over Malaya. For details of independent trials conducted by public health authorities, write to Malayan Fertilisers Limited, P. O. Box 157 Kuala Lumpur. Sole Agents for Swingfog in this area.

Insecticide applied as a fine fog penetrates more deeply than with other application methods. It reaches right through undergrowth, spreads over a wide area. Used indoors it reaches every nook and cranny. Dieldrex 15, a dieldrin solution in oil is the ideal insecticide for this purpose. The ideal machine is . . . Swingfog.



SHELL

DIELDREX 15

the ideal estate insecticide

THE EAST ASIATIC CO., LTD.

are proud to announce their appointment as sole agent

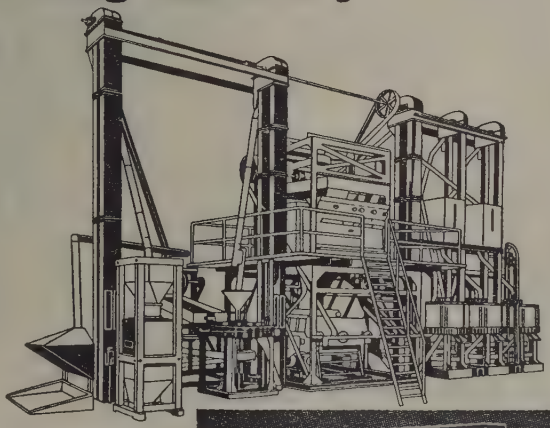
in the Federation and Singapore for

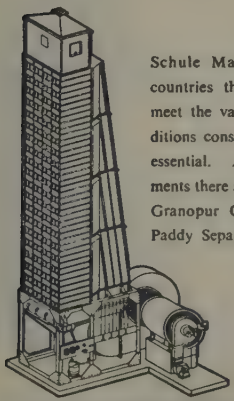
SCHULE

rice milling machinery

F H. Schule, Ltd , have been engaged in this specialist field of producing rice milling machinery for seventy years. The results of these years of experience combined with unceasing research and development are reflected in the quality of each machine; Schule Machinery is unsurpassed in efficiency, low power consumption and machine life A wide range of machinery designed to suit all needs is available and includes:-

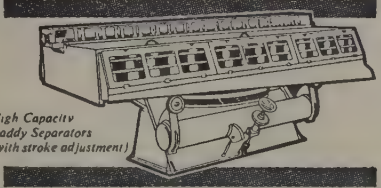
Selfcontained Rice Mills, Universal Rice Dryers, Paddy Cleaning and Grading Equipment· Husk Separators and White Rice Aspirators; Paddy Separators, Pearling and Polishing Cones; White Rice Classifying Equipment; Rice Hullers, Steam Engines;



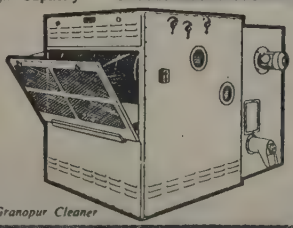


Blow-through (B.T) Universal Rice Dryer
Draw-through Universal Rice Dryers also available

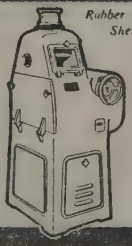
Schule Machinery is used in many countries throughout the world and to meet the varying demands of local conditions constant machine development is essential. Amongst the latest developments there are new Rubber Roll Shellers, Granopur Cleaners and High Capacity Paddy Separators



High Capacity Paddy Separators (with stroke adjustment)



Granopur Cleaner



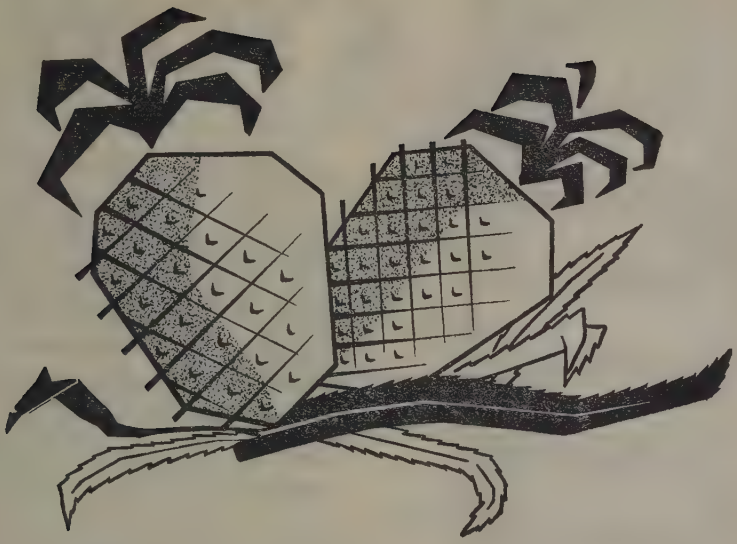
Rubber Roll Shellers

All enquiries to:-

THE EAST ASIATIC CO., LTD.

P.O. BOX 354 K. LUMPUR TEL: 88944 • P.O. BOX 41 PENANG TEL: 62371
Singapore P. O. Box 158 Tel: 33821

SAVAL
PLACE BREAST
SAVAL
SAVAL
MEDIUM PRESSURE SPRAYER
LINDETEVES
JACOBERG
For quicker and cheaper spraying! SAVAL is a medium pressure sprayer. Ideal for plantations, gardens and lawns and uses an average of 6 gallons to the acre against the usual 70.



For quick
crops and
uniform cropping
SPRAY WITH

'PLANOFIX'

trade mark *brand*

HORMONE SPRAY SOLUTION

'PLANOFIX' induces flowering, condenses the harvest into one to two weeks.
Detailed information is available on request

AN **M&B** *brand* HORTICULTURAL PRODUCT

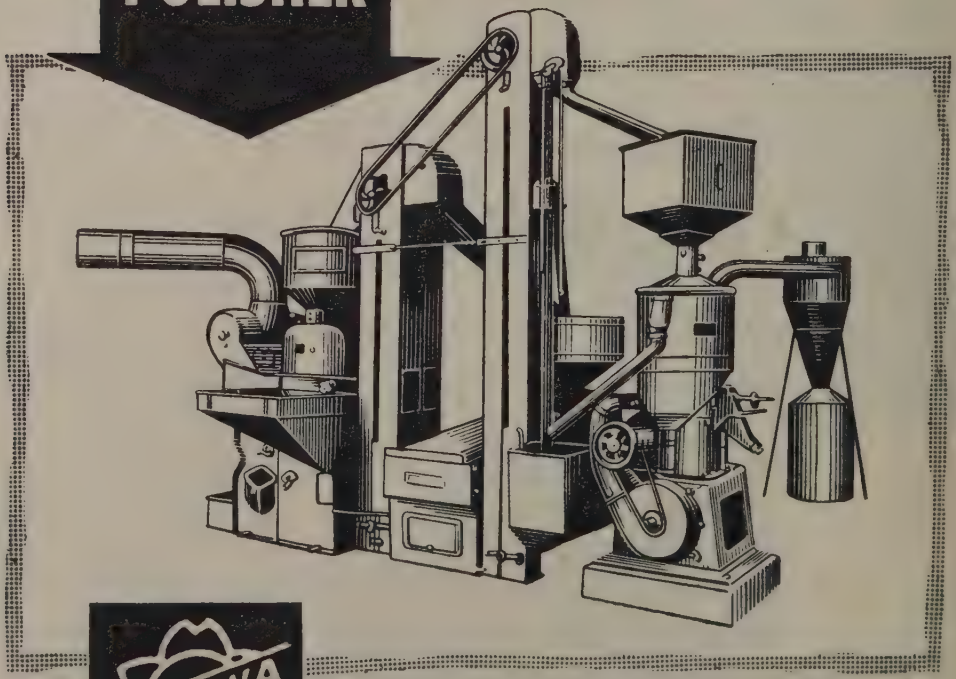
MANUFACTURED BY
MAY & BAKER LTD · DAGENHAM · ENGLAND
BRANCH OFFICE: P.O. BOX 693, SINGAPORE

HA1331.85

KYOWA

RICE MILLING UNITS COMPLETE WITH HULLER AND POLISHER

The rice-miller's boon for hulling rice with the minimum breakage and the maximum quality. This KYOWA rice-huller employs a revolutionary 'Elastic Friction' system in rice hulling which retains perfect shape and smooth surface in its natural brilliance of rice processed by it, giving longer storage life and higher market value.



KYOWA

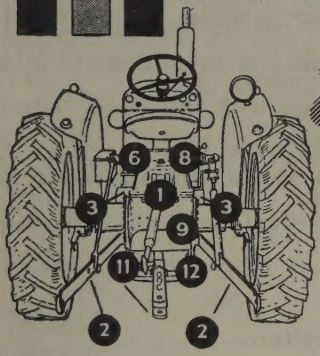
荷蘭公司

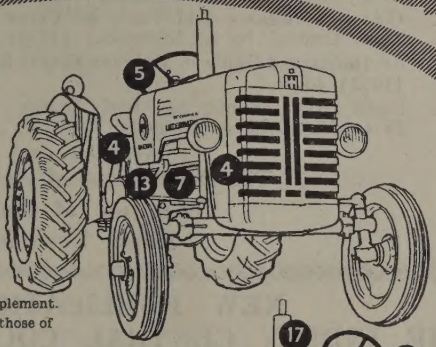
LINDETEVES JACOBERG

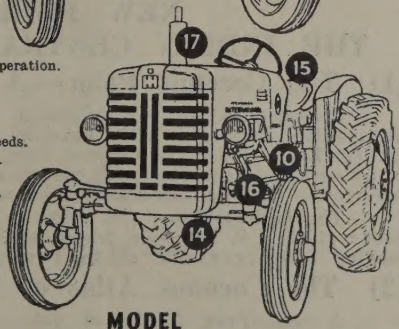
Invest in McCORMICK INTERNATIONAL DIESEL TRACTORS

IH

FOR BIGGER ADVANTAGES all round!







1 **Differential Lock** — overcomes wheel spin.
2 **Reversible 3-Point Linkage** — allows immediate use of almost any Category 1 and Category 2 implement.
3 **Self-Energising Disc Brakes** — linings long outlast those of conventional brakes.
4 **Truly 'Live' Hydraulic System** — no interruption through clutch operation.
5 **Light Steering** — eliminates steering fatigue.
6 **Separate Oil Reservoir for Hydraulics** — Light grade oil for easier winter running.
7 **Full Diesel Engine** — high lugging characteristics at all engine speeds.
8 **Weight-Transfer and Depth-Control System** — entirely mechanical — *throws no load on the hydraulics.*
9 **Power Take-Off** — delivers full B.H.P. when operating with power take-off machines built to B.S.I. p.t.o. speed standards.
10 **Five Forward Speeds** — from 1.1 to 11.4 m.p.h. *at full throttle.*
11 **Swinging Drawbar with Adjustable Frame** — for all pull-behind implements.
12 **Automatic Pickup Hitch** — easily interchangeable with linkage.
13 **Hand Parking Brake** — fitted as regular equipment.
14 **High Clearance** — 15¼ inches at lowest point of tractor.
15 **Unmatched Driving Comfort** — for *every* operator.
16 **Electric Starter Motor** — with *manual* engagement.
17 **Upswept Exhaust** — *no extra cost.*

All these features on the tractor with the really new design and with the power/weight ratio that enables you to use full throttle in every gear with the utmost fuel economy.

MODEL **B-275** - 35 H.P.
with high & low shiftlever also available.

MODEL **B-250**
DIESEL TRACTOR 30 B.H.P.

CHECK THESE FEATURES OF THE B-250 AGAINST THOSE OF ANY OTHER TRACTOR AVAILABLE.
For a demonstration of this remarkable tractor on your own farm, contact your IH dealer. No charge. No obligation.

IMPORTER:

SINGAPORE MOTORS LTD.

315-319, ORCHARD DOAD, SINGAPORE-9. TEL: 28291 (5 Lines)

MINISTRY OF AGRICULTURE AND CO-OPERATIVES
DIVISION OF AGRICULTURE

Available Recent Publications

BULLETINS

No. 101. Pot Experiments on the Insecticidal Control of Padi Stem-Borers, by LI. J. Wyatt, 1956. $1.50.

102. Field Investigations of Padi Stem-Borers, 1955-56 by I. J. Wyatt. (1957). $150.

103. The Economics of Padi Production in North Malaya, Part I, by T. B. Wilson. (1958). $3.

104. West Johore Coconut Production Survey by T. B. Wilson. (1958). $1.25.

105. Reconnaissance Soil Survey of Trengganu by Wm. P. Panton. (1958). $6.

106. Patanga Succincta (L) "The Bombay Locust", in Malaya, by H. T. Pagden. (1959). $2.

107. Mineral Deficiency Symptoms of Cacao Grown in Sand-Culture by R. G. Lockard, P. Vamathevan and S. Thamboo. (1959). $4.

108. Mineral Nutrition of the Rice Plant in Malaya, by R. G. Lockard. (1959). $6.

109. Rice Variety Trials in Malaya, 1954-58, by F. B. Brown. (1959). $3.

110. Commin Diseases and Pests of Crops in Malaya with Suggestions for Their Control, by A. Johnston. (1959). $1.

111. An Illustrated Guide to Malayan Citrus Species and Varieties, by A. Santiago (1962) $3.50.

112. Some Experiments on Soil Water Plant Relationship in Rice, by Seizo Matsushima. (1962). $1.

Available from

The Department of Agriculture,
Federation of Malaya,
Kuala Lumpur.

NEW PUBLICATIONS OF THE INDIAN CENTRAL COCONUT COMMITTEE

(1) The Coconut Palm — A Monograph :

Compiled by Dr. K.P.V. Menon, Director, Central Coconut Research Station, Kayangulam, and Dr. K.M. Pandalai, Joint Director, Central Coconut Research Station, Kasaragod, "The Coconut Palm—A Monograph" is a comprehensive treatise on all problems connected with the coconut industry and fills a long gap in scientific information that has accumulated in coconut research during the last two decades.

The book contains 384 pages of size 8¾" x 11½", 150 illustrations and 19 colour plates. It has been priced at Rs. 4¾/- Sh. 90/- $13.00 (including postage, packing and forwarding charges) a copy.

(2) The Coconut Atlas of India :

A beautifully illustrated publication containing maps, charts and graphs depicting in a simple and effective manner acreage and production of coconuts in India and the world, trends in import and export and trends in prices of coconut, copra and coconut oil in India and some of the important coconut growing countries of the world.

Beautifully printed on offset paper with rexine cover the book contains 88 pages of size 11½" x 9" and is priced at Rs. 18/- Sh. 40/- $6.00 (including postage, packing and forwarding charges) a copy.

For copies please write to:—

THE SECRETARY,
Indian Central Coconut Committee,
Ernakulam.

DEPARTMENT OF AGRICULTURE, FEDERATION OF MALAYA.

The Director of Agriculture invites those interested to visit the College of Agriculture, Serdang, Selangor, and the various Federal and State Stations throughout the Federation of Malaya. Intending visitors to the College of Agriculture should communicate with the Principal; to the Federal Experiment Station, Serdang, Selangor, with the Agronomist-in-charge; and to other Federal and State Stations with the State Agricultural Officers. The following is a list of Agricultural Stations on which can be studied the more important lines of investigation and extension at present carried out by the Department.

Correspondence concerning the experiments at any of these Stations should, if it originates in Malaya, be addressed to the State Agricultural Officer, concerned; correspondence originating in any other country should be addressed to the Director of Agriculture, Federation of Malaya, Kuala Lumpur.

Wet Padi.

SELECTION WORK. Telok Chengai, Kedah; Titi Serong, Simpang Tiga and Talang, Perak; Pulau Gadong, Malacca; Kota Bharu and Jelawat, Kelantan; Kendong, Ulu Klawang and Ampang Tinggi, Negri Sembilan; Tangkak, Johore; Genting and Bukit Merah, Penang and Province Wellesley; and other State Stations.

AGRONOMIC INVESTIGATIONS. Several Padi Experiment and Test Stations.

PADI MECHANISATION SCHEME, Parit, Perak.

Dry Padi.

Melor, Kelantan, and Paya Besar, Pahang.

Rubber.

Budwood and clonal seedling nurseries. Most State Agricultural Stations. Replanting demonstration plots in all States.

Tea.

Federal Experiment Stations, Cameron Highlands and Serdang.

Oil Palm.

Federal Experiment Stations, Serdang, Selangor, and Jerangau, Trengganu.

Coconut.

Federal Experiment Station, Telok Bharu, Perak, and Coconut (Rehabilitation) Station, Sungei Sudah, Muar, Johore.

Cacao.

FEDERAL EXPERIMENT STATIONS. Serdang, Selangor, and Jerangau, Trengganu.

AMELONADO SEED GARDENS. Sik, Kedah; Batang Merbau, Kelantan; Ayer Itam, Penang; Layang Layang Kiri and Bukit Gantang, Perak; Temerloh, Kuala Lipis and Pekan, Pahang; Ampang Tinggi, Negri Sembilan; Sungei Udang, Malacca; Ayer Hitam, Tangkak, Johore; Sungei Tong, Trengganu.

Peat Soil.

Jalan Kebun, Selangor.

Manila Hemp.

Federal Experiment Station, Serdang, Selangor; Degong, Perak; and Sungei Ruan, Pahang.

Fruit Propagation.

Federal Experiment Station, Serdang, and all State Agricultural Stations.

Vegetables.

Federal Experiment Stations, Kuala Lumpur and Cameron Highlands.

Poultry.

Federal Experiment Station, Cameron Highlands and most State Agricultural Stations.

Livestock.

PIGS: Federal Experiment Stations, Serdang and Cameron Highlands; Sungei Buloh and Jenjarom, Selangor; Mah San, Negri Sembilan; Raja Hitam (Dindings), Perak; Pulau Gadong, Malacca; and Ayer Itam, Penang.

GOATS: Ayer Itam, Penang; Bukit Mertajam, Province Wellesley; Sungei Udang, Malacca; Cheras, Setapak, Sabak Bernam and Federal Experiment Station, Serdang, Selangor; Chembong, Negri Sembilan.

Pastures.

Federal Experiment Station, Serdang, Selangor.

Printed by
The Economy Printers Ltd.
Kuala Lumpur.
1135-62